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The impact of scenarios and personas on requirement elicitation : an experimental study

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THÈSE

Pour obtenir le grade de

DOCTEUR DE L'UNIVERSITÉ DE GRENOBLE

Spécialité : **Génie Industriel**

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Présentée par

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Thèse dirigée par **Eric Blanco** et
codirigée par **Franck Pourroy**

préparée au sein du **Laboratoire G-SCOP**
dans l'**École Doctorale Ingénierie, Matériaux, Mécanique,**
Energétique, Environnement, Procédés, Production

Impact des approches « scénario » et « persona » sur l'élicitation des exigences : une étude expérimentale

Thèse soutenue publiquement le **7 Février 2011**
devant le jury composé de :

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“Science is the most reliable guide for civilization, for life, for success in the world. Searching a guide other than the science is meaning carelessness, ignorance and heresy”

M. Kemal Ataturk

Résumé en Français

Contexte de Recherche:

La problématique centrale de la thèse est l'évaluation de l'impact de démarches utilisant la formulation de scénarios et de personnages sur les phases d'expression des besoins en conception innovante. La méthodologie de recherche mise en œuvre est une démarche empirique qui s'appuie sur l'analyse de situations de conception. Au cours du doctorat, un protocole expérimental mis en œuvre a été dupliqué trois fois dans des laboratoires partenaires. Cette recherche aboutit à un mémoire de thèse qui présente plusieurs contributions :

- La première contribution se situe autour de la méthodologie de recherche proposée. Le protocole d'étude empirique mis en place est original, il s'appuie sur l'état de l'art des réflexions de la communauté et sur ces démarches de recherche, et propose des éléments nouveaux à cette réflexion en conciliant approches quantitatives et qualitatives.
- La seconde contribution porte sur la caractérisation de l'impact des méthodologies étudiées sur la construction d'une représentation partagée du problème de conception et de la formalisation des exigences de conception.
- Enfin la troisième contribution porte sur l'analyse des interactions dans les activités de conception étudiées. Les analyses identifient et qualifient les impacts des méthodes étudiées sur le contenu des interactions dans les phases amont de la conception.

Mots-clés: Conception basée sur les scénarios, personnages, développement de produit nouveaux, définition des exigences, connaissance partagée, expérimentations.

Chapitre 1-Introduction

Dans le cas actuel, en regardant le changement rapide des environnements de production, la capacité de satisfaire les besoins des utilisateurs est un avantage important pour les entreprises. En conséquence, la modernisation des entreprises conduit à créer de nouvelles organisations de conception qui permettent de concevoir des produits qui sont guidés par les besoins des utilisateurs. Cette thèse se focalise sur l'activité de définition de ces besoins, leur appréhension, leur communication entre les concepteurs, et leur transformation en une liste d'exigences à satisfaire par un produit nouveau.

Pour définir les besoins, les concepteurs se focalisent de plus en plus sur les utilisateurs. Leur diversité est considérée, comme leur âge, leurs connaissances, leur sexe, etc. Plusieurs approches de conception placent les utilisateurs au centre du processus, quand les autres les intègrent directement dans le processus de conception. La conception centrée utilisateur (UCD) permet aux utilisateurs d'exprimer leurs besoins, leurs préférences et de partager leurs savoir-faire (Kynig 1994). Ainsi, les concepteurs sont capables d'évaluer le produit aussi tôt que possible dans le processus de production. D'un autre côté, dans la conception participative (PD), les utilisateurs ne sont pas seulement la source d'information, mais participent aussi à la prise de décisions (Schuler and Namioka 1993).

Pourtant, ces approches montrent leurs limites dans la capacité des utilisateurs à imaginer des solutions techniques faisables. De plus, pendant le développement de produits nouveaux (NPD), puisqu'il n'y a pas de produit existant ou d'utilisateur identifiable, il est difficile de réunir des informations utilisateur et d'assurer une représentation des besoins par les différents acteurs de la conception (Redstrom 2008). Cela montre que les équipes de conception ont besoin de renouveler leur manière d'appréhender le produit.

D'un autre côté, chaque concepteur a une représentation plus ou moins partielle, plus ou moins bonne, de l'usage du produit qu'il développe. En effet, il est parfois difficile dans le processus de conception d'avoir une connaissance partagée des utilisateurs finaux et de leurs exigences (Hey et al. 2007), ce qui semble pourtant nécessaire pour le succès du produit (Cooper and Kleinschmidt 1993). Il en résulte un écart dans lequel la valeur du produit a été dissoute.

Pour résoudre ces problèmes, des méthodes existent et peuvent être utilisées en tant que support pour les concepteurs. Mais l'adéquation et l'efficacité des différentes méthodes ne sont pas connues correctement. La conception basée sur les scénarios (SBD) (Carroll 2000) et Personas (Cooper 1999) sont de plus en plus utilisés dans le domaine de l'interface homme-machine et de la conception de logiciels/systèmes. Elles se focalisent sur la description des utilisateurs, et sur leurs interactions avec le produit à développer. Notre hypothèse est que l'utilisation des scénarios et Personas comme « objets intermédiaires » peut aider les concepteurs, d'une part à éliciter les exigences des utilisateurs finaux, et d'autre part à construire une compréhension partagée de ces besoins dans le processus de conception de produits nouveaux.

D'où une problématique centrale de la dissertation présentée dans ce document, relative à l'évaluation de l'impact des démarches utilisant la formulation de scénario et des Personas sur les phases d'expression de besoin en conception innovante.

Questions de Recherche:

Nous avons structuré notre travail de recherche sur la phase de définition des besoins d'utilisateurs finaux autour de deux questions de recherche et une sous-question.

(RQ1) Quels sont les impacts des scénarios et Personas pour définir les exigences des utilisateurs finaux ?

(RQ2) Quels sont les impacts de scénarios et Personas pour avoir une compréhension partagée par les concepteurs, des utilisateurs finaux et de leurs exigences ?

Ces questions de recherche nous amènent à la question, comment peut-on évaluer les impacts de ces méthodes. Dans cette thèse on fait l'hypothèse que l'approche expérimentale peut être utilisée pour évaluer ces impacts. Ceci nous amène à une sous-question relative à l'adéquation de cette méthodologie.

(SQ1) Peut-on utiliser l'expérimentation comme méthodologie de recherche pour évaluer ces impacts ?

Chapitre 2- Revue de la littérature

La thèse se focalise sur les phases amont de conception de produits nouveaux, pendant lesquelles les exigences des utilisateurs sont élicitées et formalisées. Ainsi, la revue de la littérature est conçue en cinq parties : le processus de conception, la définition des concepts, l'analyse des exigences, les approches centrées utilisateurs, et les techniques pour définir les exigences. Le but était de se questionner sur :

- Qui sont les utilisateurs ?
- Comment définit-on et formalise-t-on leurs exigences?
- Quels sont les problèmes rencontrés pour définir les exigences des utilisateurs ?

- Quelles sont les techniques et les approches qui focalisent sur les exigences des utilisateurs pendant la conception de nouveaux produits ?

Cette revue nous a permis d'un côté de définir et détailler les termes utilisés dans la littérature afin de clarifier le langage de cette thèse, et d'un autre côté de préciser nos questions de recherche.

Chapitre 3 – Scénarios et Personnages

Ce chapitre inclut une revue de littérature et de discussion plus détaillée sur les réels intérêts de la recherche : conception basée sur les scénarios et Personas. Ces deux approches sont présentées et analysées sous différentes perspectives. Le chapitre focalise plus sur comment elles sont construites et utilisées pendant la phase amont de la conception d'un nouveau produit.

Un scénario est décrit comme « l'histoire de personnages et leurs activités ». L'idée générale est de créer plusieurs situations qui décrivent les intérêts et l'usage d'un nouveau produit ou service pour ses utilisateurs. Les scénarios exposent non seulement les fonctionnalités du système/produit, mais aussi la façon dont l'utilisateur aura accès à ces fonctionnalités. Le scénario inclut également des agents et des acteurs à identifier. Chaque personnage a des objectifs à atteindre. Les utilisateurs finaux sont représentés par les personnages imaginaires dans les scénarios.

Plusieurs médias sont discutés pour la présentation des scénarios, comme les story-boards, les vidéos, les textes, etc. Des exemples d'utilisations sont présentés et leurs avantages et inconvénients sont comparés. Le contenu des scénarios dans les différentes phases de conception est expliqué. Cette revue a montré que dans les phases amont les concepteurs utilisent plutôt des scénarios incomplets, moins détaillés. Ils préfèrent aussi utiliser les médias faciles à mobiliser et modifier comme les story-boards.

Cette revue de la littérature a renforcé notre hypothèse selon laquelle les scénarios et Personas peuvent être utilisés pour définir les besoins d'utilisateurs finaux et avoir une connaissance partagée entre les concepteurs.

Chapitre 4 – Méthodologie de Recherche

Ce chapitre commence par une comparaison entre les approches ethnographique et expérimentale en tant que méthodologie de recherche. Puisque l'idée est de vérifier une hypothèse plutôt que d'en faire émerger de nouvelles, l'approche expérimentale est retenue. La

méthodologie commence par la définition d'une hypothèse scientifique. Une expérience est ensuite conçue et mise en œuvre pour l'évaluation de cette hypothèse.

La conception d'une expérience structurée est discutée au cours de trois sous-sections :

- 1) structure de l'expérience : différentes structures d'expériences sont discutées et l'approche « quasi-expérimentale » est choisie afin de ne pas attribuer les participants dans les groupes au hasard,

- 2) description de la situation de conception : la situation de conception est décrite par quatre éléments de base : la tâche, l'acteur, l'objet et l'environnement en se basant sur le modèle de Prudhomme et al. (Prudhomme et al. 2007)

- 3) processus expérimental : il est structuré par cinq étapes : monitoring, enregistrement, analyse, préparation et intervention (Hicks et al. 2009).

Ensuite, l'expérience conçue sera évaluée du point de vue de sa validité, de sa reproductibilité, et de sa fiabilité (Bryman 2001). Une fois l'expérience validée, les résultats seront analysés et jugés pour la validation de l'hypothèse.

Chapitre 5 – Conception de l'expérience

En se basant sur la méthodologie définie dans le chapitre précédant, une expérience est conçue et réalisée. L'expérience inclut deux groupes de participants : un groupe utilise les approches scénarios et Personas pour définir les exigences des utilisateurs finaux (groupe B), n'utilise pas ces approches (groupe A). Dans chaque groupe, il y a quatre participants. Les groupes sont construits de manière similaire par rapport à leur background, âge, éducation, etc.

L'expérience contient trois étapes principales et deux étapes amont. Dans les phases amont, les participants sont formés aux méthodologies qu'ils vont devoir utiliser pendant l'expérience. La formation est faite au travers d'un document qui leur est transmis quelques jours avant l'expérience. Une présentation est aussi faite juste avant l'expérience pour en expliquer les différentes étapes. La tâche de conception assignée aux participants consiste à lister, au cours d'une réunion, les fonctions principales d'un nouveau produit : un calendrier digital mural. Les participants sont aussi chargés de réaliser des tâches individuelles avant et après cette tâche collective. Les tâches individuelles permettent aux participants de se familiariser avec le problème de conception. Elles sont aussi utilisées pour mesurer le changement réalisé pendant la réunion. Le but est de comparer les résultats de entre les groupes utilisant les scénarios et Personas, et ceux qui ne les utilisent pas.

Le processus d'expérience est structuré en cinq étapes : monitoring, enregistrement, analyse, préparation et intervention. Dans la phase de monitoring, une salle d'observation est préparée pour nous permettre d'enregistrer les réunions collectives. Les différentes phases de l'expérience sont aussi discutées et standardisées dans cette étape. Pendant l'étape d'enregistrement, plusieurs types de données sont enregistrés : enregistrement vidéo de la réunion, capture de tous les objets intermédiaires créés et utilisés pendant l'expérience, etc. La phase d'analyse se focalise sur, d'une part l'évaluation de l'expérience, d'autre part les questions de recherche. Des analyses qualitatives et quantitatives sont appliquées aux données collectées et les résultats sont présentés dans le chapitre suivant. Les étapes de préparation et d'intervention constituent, quant à elles, le sujet du chapitre conclusion et perspectives.

Chapitre 6 – Analyse

Ce chapitre présente en détails les méthodes d'analyses utilisées. Nous avons conduit huit séances d'expériences dans des laboratoires différents, qui respectent la même procédure et qui sont préparées dans deux langues (anglais et français). C'est ainsi que la reproductibilité de l'expérience est démontrée. La fiabilité des données est analysée dans deux étapes : une analyse globale et une analyse détaillée basée sur la communication verbale des participants.

Les questions de recherche sont traitées par sous-catégories. Pour répondre à la question « Quels sont les impacts de scénarios et Personas pour définir les exigences des utilisateurs finaux ? », on a évalué les impacts de ces méthodes sur :

- le nombre de fonctions définies dans chaque groupe,
- la richesse des discussions autour de ces fonctions,
- la capture de la logique de conception,
- la création d'empathie,
- l'ambiance de la réunion

D'autre part, pour répondre à la question « Quels sont les impacts de scénarios et Personas pour avoir une connaissance partagée entre les concepteurs des utilisateurs finaux et de leurs exigences ? », on a évalué leurs impacts sur :

- la clarification des perspectives
- la convergence des perspectives

Chapitre 7– Résultats

Les résultats de ces analyses peuvent être résumés comme suit :

- Les difficultés d’avoir une compréhension partagée entre les concepteurs :

Comme discuté au chapitre précédent, la notion de « compréhension partagée » est discutée dans cette thèse en deux sous-catégories : clarification des perspectives, et convergence des perspectives. Les résultats d’analyse ont montré que les concepteurs ont eu des difficultés pour se faire comprendre et converger vers une liste commune des exigences produit à satisfaire. Après avoir discuté une heure et demie sur les utilisateurs et leurs besoins, il y avait encore des conflits, ou au moins des différences, sur la façon dont ils ont décrit l’utilisateur et les fonctions principales des produits. Entre huit groupes d’expérience, il n’y avait aucun groupe qui ait partagé la même liste de fonctions principales du produit. D’un autre côté, les participants n’étaient pas toujours conscients de leurs conflits ou accords. Pour des projets de longue durée et des produits plus complexes, ces résultats montrent les difficultés de situation et soulignent l’importance de recherches sur la question ; comment peut-on soutenir les concepteurs pour faciliter leurs communications et partager leurs connaissances.

- Les concepteurs ont une tendance à utiliser les scénarios en discussion :

Dans les groupes où il n’était pas demandé d’utiliser les scénarios et Personas en tant que méthode support pour décrire les utilisateurs finaux et de définir leurs besoins, il y avait quand même plusieurs « fragments de scénarios » discutés. Cela montre que les concepteurs utilisent naturellement les scénarios en discussion sans en avoir conscience. La méthodologie conception basée sur les scénarios fortifie ce processus, et aide les concepteurs à créer des scénarios plus complets et à être plus conscients de ces scénarios.

- La vague définition du terme « scénario » empêche une utilisation efficace:

On a remarqué que la définition du terme « scénarios » : « histoires des personnages et de leurs activités » est très vague pour les concepteurs. Pendant l’entretien que l’on a réalisé après la réunion collective, on a remarqué que les concepteurs n’avaient pas la même définition pour le même terme. Les questions, telles que : à quel niveau un scénario contient des détails, combien de scénarios faut-il créer pour un projet, quand un fragment scénario devient-il un scénario complet, etc., compliquent leur utilisation effective.

- L’impact majeur des scénarios et Personas est de créer de l’empathie avec les utilisateurs finaux :

Les résultats ont prouvé que les scénarios et personnages aident les concepteurs à se focaliser sur les besoins des utilisateurs finaux et à créer l'empathie. En l'absence de ces méthodes, les concepteurs ont tendance à se focaliser sur eux-mêmes ou sur les gens autour d'eux, comme leurs enfants, leurs voisins etc.

- Scénarios et Personas enrichissent les discussions :

Les groupes qui ont utilisé les scénarios et Personas ont discuté sur plus de fonctions et de manière plus détaillée par rapport aux groupes qui ne les ont pas utilisé. Les discussions autour d'une fonction ont aussi duré plus longtemps.

- Scénarios et personnages changent l'ambiance de réunion :

Les groupes qui ont utilisé ces méthodes n'ont pas eu moins de difficulté à entretenir des discussions fournies. Il y avait une bonne ambiance au cours de la réunion. Discuter autour de personnages imaginaires a permis aux concepteurs d'être plus détachés et de sentir plus confortable à critiquer, proposer des idées, argumenter, etc. Dans les autres groupes, il y a eu plusieurs moments de silence et les participants se sont sentis maladroits.

- Scénarios et Personas sont prometteurs pour la capture de la logique de conception

L'analyse de la discussion des participants montre que la capture de scénarios peut aider les concepteurs à garder des traces de la logique de la conception. Par contre, entre les groupes qui ont utilisé ces méthodes n'ont pas, ou très peu, capturé les scénarios créés. Ils les ont utilisés comme support à la discussion plutôt qu'un outil de documentation.

- On ne peut pas vérifier que scénarios et personnages ont un effet significatif sur la convergence des perspectives

Même si les analyses qualitatives ont montré que l'utilisation de scénarios et Personas aide à l'argumentation et à la négociation, les analyses quantitatives ont montré que les groupes qui utilisent ces méthodes n'ont pas des résultats significativement différents par rapport aux autres groupes. Le faible nombre d'expériences réalisées a joué un important rôle dans cet aspect, conduisant à des résultats contradictoires d'un groupe à l'autre.

- On ne peut pas vérifier que scénarios et Personas ont un effet significatif sur la clarification des perspectives

Pareillement avec les résultats de l'évaluation sur la convergence des perspectives, les analyses qualitatives ont prouvé que les concepteurs s'appuient bien sur ces méthodes pour clarifier leurs perspectives. Par contre, sur les analyses quantitatives, réalisée à partir des productions individuelles antérieures et postérieures à la réunion, les résultats obtenus sont là aussi contradictoires.

Chapitre 8 – Conclusions et perspectives

Pour conclure, cette thèse s'est focalisée sur deux questions de recherche. On a présenté dans cette recherche d'une part les résultats obtenus qui répondent à nos questions de recherche, d'autre part une approche expérimentale comme méthodologie de recherche en conception. L'étude des impacts des approches scénarios et Personas conduit à des résultats contrastés, qui montrent des différences notoires entre les réunions réalisées avec et celle réalisées sans ces méthodes, sans pour autant que ces différences conduisent à des améliorations mesurables au niveau des livrables produits par les différents groupes. Les raisons à cela sont discutées plus en détails dans ce chapitre. Le bienfondé d'une approche expérimentale pour évaluer l'efficacité des méthodes de conceptions est également démontré par cette étude, mais si certaines limites sont mises en avant et discutées.

Nous identifions plusieurs perspectives possibles afin de continuer cette étude :

- Focaliser plus sur le problème d'avoir une compréhension partagée: Les résultats montrent l'importance de réaliser des recherches sur ce problème. Une analyse plus détaillée peut être réalisée sur les enregistrements vidéo de nos expériences pour définir les impacts qui renforcent la connaissance partagée entre les concepteurs. Ces analyses peuvent être utilisées pour la conception d'outils interactifs qui informent les concepteurs sur leurs niveaux de connaissances partagés.
- La conception d'outils d'aide à la création et à la capture de scénarios : les analyses ont montré que les outils fournis aux concepteurs n'étaient pas ergonomiques pour créer et capturer les scénarios. Une revue de la littérature a aussi montré la nécessité de se focaliser sur ce sujet.
- Méthodologie de recherche : Monter une expérience et en analyser les résultats prennent beaucoup de ressource et de temps, ce qui nous a limités dans le nombre d'expériences réalisées et analysées, ne permettant pas de proposer de conclusions solides sur l'ensemble des questions abordées. Cela montre l'importance de créer une salle « d'observation intelligente » qui permettrait d'automatiser une partie des

expériences. Il serait par exemple intéressant que les transcriptions de réunions puissent être analysées automatiquement pendant la réunion par rapport à des indicateurs définis par avance. Ces informations pourraient alors être intégrées aux réunions en tant que retour d'expérience.

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Abstract

In this study, we are more concerned with the early stages of the new product design: the product definition phase. The fundamental purpose of this phase is to gather right kind of information in a way that allows the formalization of stakeholder needs into a set of requirements. Literature review on this phase shows the difficulty to elicit needs of so called intended users and have a shared understanding of their requirements between design actors. To overcome these obstacles, support methods can be used. However, the appropriateness and effectiveness of the various methods is unknown.

Our assumption in this research project is that scenarios and personas can be used as support methods to handle above-mentioned obstacles. An experiment is designed and conducted in a laboratory environment in order to test this assumption. The question of whether they have an impact on the creation of shared understanding between design actors is discussed under two sub-categories: perspective clarification and convergence to a common perspective. On the other hand, their impact on the elicitation of the intended user requirements is observed under three sub-categories: requirement elicitation, capture of the design rationale and creation of the empathy.

Some qualitative and quantitative indicators are proposed to evaluate these impacts. Based on the analysis of seven observed collaborative design sessions, the findings of research study are discussed. The results points out that the major impact of these methods is that they evoke empathy for the intended users. In the groups that these methods are used the discussions are also richer regarding to the number of different needs are addressed. Moreover, these methods are also promising to keep the trace of design rationale. However design actors have tendency to accept them just as communication support, rather than documentation one. As a communication support they help design actors to clarify their arguments, to negotiate and to take decisions. However, the findings were not adequate to conclude that they have a significant impact on the perspective clarification and convergence.

Hence, the main contribution of this research lies from one part in the evaluation of the impacts of these methods in requirement elicitation activity. And, in other part description of a research approach, which guides the experimental study in engineering design.

Chapter 1 Introduction

In this chapter the problem statement is introduced and the background of the problem is described. Afterwards, the objectives of the study are explained, and research questions are derived. Finally, the structure of the thesis is presented.

1. Introduction

In today's rapidly changing production environment, the ability to satisfy users' requirements is a key competitive advantage. The main focus of this thesis is the requirement elicitation activity that the users' needs are discovered, understood, communicated, and transformed into a set of requirements that are going to be satisfied by the new product. When users are not considered as important in the early stages of the design process, then a wrong product might be defined and launched, which is unattractive to the users and unprofitable to the firm. The aim of requirement elicitation activity is then to be sure that a right and good product is defined and developed from the users' point of view.

In order to elicit information about what is needed, design actors then focus more and more on the users. Their diversities are also considered, like skills, knowledge, age, gender, etc. Many design approaches place them at the centre of the process, while as the others integrate them directly in the design process. Hence, the users not only evaluate the product, but also are a part of the design process since the early stages. However, in the early stages of the new product design, the users are not always defined sufficiently well enough to clearly identify their needs or for being involved in the design process. Thus, design actors recognize the need for methods that will allow considering so-called intended users and their needs even in the early stages of the new product design process.

Another obstacle in new product design process is that each design actor may interpret intended users and their needs differently and become sensitive to different product constraints. The lack of shared understanding among design actors may cause difficulties in defining requirements and cause non-convergent design processes. Then, methods are also expected to support shared understanding between design actors.

To overcome these obstacles, some existing methods might be used in order to support the requirement elicitation activity. However, the appropriateness and effectiveness of the

various methods are unknown. In the literature, personas (Cooper 1999) and scenarios (Carroll 2000) are discussed to be promising in that purpose. Their usage is becoming more and more popular, especially in Software and System Engineering and Human Computer Interaction (HCI). In this study, we focus on the impact of scenarios and personas in the requirement elicitation activity for the new product design process in order to overcome the above-mentioned obstacles.

1.1. Need for design methods to elicit intended user needs

Research studies carried on the product success underlines the importance of satisfying user needs (Cooper 1996). Design approaches then consider users since the early stages of the design process. This consideration may cover different levels of user involvement in the design process, such as focusing on users, consulting users, contacting with users, and co-creating with users. Several support techniques also exist for supporting the user consideration in requirement elicitation activity, such as interviews, focus groups, etc. (for an overview see (Lofthouse and Lilley 2006; Coulin 2007)).

Most of these methods focus on interrogating and listening what the users want. However, the users are not always able to state their knowledge and needs concisely in response to direct questions. These methods remain also unhelpful, when a company works on a new product that is not tied to familiar user paradigm, which means there is no intended user to ask or observe (Leonard and Rayport 1997). Moreover, it is difficult to define who the intended users are, before defining the usage of the product (Redström 2006). Similarly, if there is no similar product on the market, the intended users have no reference, on which to formulate their opinions. No one will ask for a technology that they do not know if it is feasible.

Thus, the design actors need supporting methods that will help them to imagine and focus on the intended users. Scenarios and personas are discussed to be useful for these purposes. While personas are used in the literature to imagine the characteristics of intended users (education, skills, experiences, etc.) and their goals (objectives of doing these task, frequency, etc.), the scenarios are used to describe the work context. Then, our first objective is to test, whether scenarios and personas have an impact on eliciting intended user requirements.

Q1: What is the impact of scenarios and personas on eliciting intended user requirements?

1.2. Need for methods to ensure shared understanding between design actors

During the concept development step of the new product design, as mentioned previously the intended users are generally not well defined and the preliminary requirements are also incomplete and contain ambiguities. Furthermore, the design actors bring with them their own beliefs, responsibilities, language, interests, jargon, and knowledge to the design team, (in Bucciarelli's term "object-worlds" (Bucciarelli 1988)). So, each design actor has his/her own "frames", which means "*underlying structures of beliefs, perceptions and appreciations*" (Schön and Rein 1995), that guide his/her interpretations and actions. In other words, the individual perspectives of the design team members may differ. Moreover, design actors might have difficulties to clarify their perspectives to each other or they might have difficulties to negotiate on the conflicting perspectives, which can cause the difficulty to converge to a common perspective. As a result of this, each design actor may interpret the intended users and their requirements differently and become sensitive to different product constraints (see Figure 1). Hence, in this study the notion of *shared understanding* between the design actors is discussed under two sub-categories: perspective clarification and convergence.

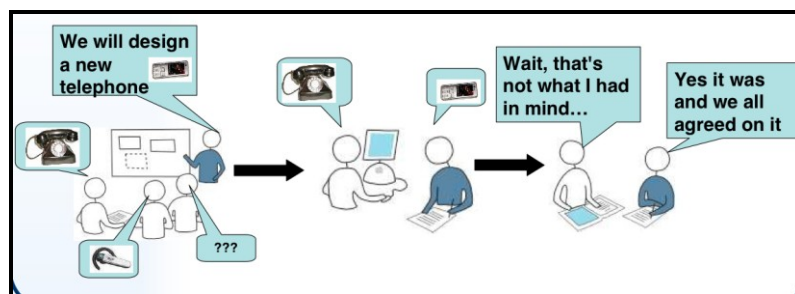


Figure 1 Problem of shared understanding between design actors

The perspective clarification is considered to be crucial for the quality of interaction (Clark and Brennan 1991). It helps to identify the conflicts among these different perspectives. Throughout the design process, these conflicts can be debated and argued, and then a common perspective can be negotiated (Détienne 2006). In other words, design actors can converge to a common perspective. The shared understanding is discussed in the literature as a condition for the design team success (Dong 2005; Valkenburg 1998). Similarly, the lack of shared understanding on the intended users and their needs among design actors is claimed to cause non-convergent design process (Hey et al. 2007) and product failure (Cooper 1996). So, for an effective product definition, the design actors need to clarify their perspectives on the intended users and their requirements and negotiate on a common one.

Thus, on the one hand, the design actors need support methods, which can provide them with some means to communicate and externalize their individual perspectives in a way that what they are thinking can be understood properly. On the other hand, they also need for methods that will support negotiation mechanism that they can be persuaded to adopt the same way of thinking on the design task. Previous researches on scenarios and personas show that they are promising for that purpose, but there is not a structured study conducted to evaluate their impact on shared understanding among design actors. Then, in this study, the second research question is that, whether scenarios and personas can be used as support methods for ensuring shared understanding of intended users and their requirements among design actors.

Q2: Do the scenarios and personas have an impact on ensuring shared understanding of intended users and their requirements among design actors?

1.3. Need for research approaches to evaluate the existing methods

In this study, based on the literature review we make the assumption that the scenarios and personas can be used to deal with the above-mentioned obstacles. Many previous studies discussed the effectiveness of these methods. However, on the one hand, the benefits are generally not clearly established that they are generally limited with the researchers' own impressions. Even if, it is useful to learn from the experiences of the others, the benefits might be limited with the scope of the discussed studies. Similarly, no formal comparative study seems to have been carried out on this matter. On the other hand, these studies are commonly carried out in system and software design, while our research focuses on the product design process. The product development differs from software development "*in the formers' more varied context of use, broader characteristics of users and more tangible solutions*"(Anggreeni and van der Voort 2008).

In order to deal with the research questions, our assumption is that the experiments can be used as a complementary research methodology to the existing studies. Although the outcomes of the experiments are testable and trustful (Bryman 2001), there are rare applications of the experiment as a research methodology in the engineering design domain (Blessing and Chakrabarti 2009). Thus, another sub-research question arising from the main questions is whether we can

SQ1: Can we measure the impact of these methods with an experimental study?

2. Outline of the thesis

This thesis begins with an introduction and background to the research problem, and a presentation of the research questions (Chapter 1). The main structure of the thesis consists of three main parts with two chapters in each:

Part 1-Theoretical Background

The first stage of the research is a literature review, which provides some definitions, details the focused obstacles that are confronted during requirement elicitation activity, and gives a brief description of the methods that can be used to deal with these problems (Chapter 2). Because the scenarios and personas are decided to be more promising methods after this literature review, a more thorough literature review is performed on these methods (Chapter 3). The objective is to observe how these methods are created and used in the design process, and what are their main roles. Their discussed strengths and shortcomings are also highlighted. This review reinforces our assumption that these methods can have an impact on eliciting intended user requirements and having a shared understanding of them between design actors. Hence, Part-1 provides a theoretical foundation for this research study.

Part 2- Research and Experiment Design

The empirical studies are considered to be more related research methodologies that can be adopted to test our assumption. After a comparison of different methodologies, the experimental study is judged to be more adapted to address our research objectives. A reviewing of different available literature is performed to determine how an experiment can be designed, carried out, evaluated, and the outcomes can be analysed. Hence, a structured research methodology is deduced and adopted (Chapter 4). By taking this research methodology as a reference, a laboratory experiment is designed and the protocol of the experiment is evaluated. The experiment design process is described and expanded (Chapter 5). So, the Part-2 is dedicated to the description of research methodology and experiment design process.

Part 3- Results

The experiment study has been conducted four times. In order to ensure its replicability, the same study is carried out in three different laboratories with the same protocol prepared both in English and French. As a result, seven co-located design sessions are captured with the duration of one and half hour for each. Some indicators are proposed, which are used to analyse the outcomes of these studies in order to deal with the research questions (Chapter 6). The

findings of the analysing process are then presented and interpreted (Chapter 7). To summarize, Part-3 presents the way that the gathered data is analysed, and also discusses the findings of these analysing activities.

Part 1-Theoretical Background

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Chapter 2 Literature Review

This chapter describes the theoretical background, on which this research work is based. We firstly give our understanding on “design” and “design process”. Secondly, a brief literature review on requirement analysis is discussed. We then focus more on the design approaches that consider user aspects as essential, since the early stages. Lastly, techniques to elicit user needs, which are used in these approaches, are discussed.

1. Introduction

In this chapter, we talk about past studies tackling the aspects that are the major concerns of this project. Firstly, we describe our understanding on design and design process, and concentrate on the concept development step. Thereafter, we focus our attention on requirement analysis, and detail the obstacles, which are going to be studied in this research project. In section four, we present the approaches that place the users at the centre of the design process, as a solution to these obstacles. The final section presents the user need elicitation techniques used in these approaches. Among these techniques, we concentrate in this study on scenarios and personas, which are presented in this chapter and will be detailed and expanded in the next chapter. Subsequently, in concluding remarks we discuss about the deduction of this literature review.

2. Design Process

Nowadays, a majority of the industrial organizations have shifted from a hierarchical structure to a more transversal one. Concurrent Engineering (Solhenius 1992) is an example of this organizational mode, where the various engineering activities in the product development and production development process are integrated and performed as much as in parallel rather than in sequence. The design process of a product is then a collective and collaborative activity (Norell 2000). Due to its collective nature, designers engaged in different tasks can coordinate their activities on the basis of disciplinary rules, individual experience (asynchronous activities) and exchange of information with the other members of the group (synchronous activities). Bucciarelli (Bucciarelli 1988) interprets that “*Design’s state is not the possession of any one individual to describe and completely define, although participants have their individual views, their own images and thoughts, their own sketches, lists, diagrams, analyses, precedents, pieces of hardware, and now spreadsheets, which they construe as the design*”. The author accepts the

design as a *social process*. Similarly, with his substantial study on design as a social process (Bucciarelli 1988), the design is considered as a social process by many other researchers (e.g. (Lloyd 2000; McDonnell and Lloyd 2009))

Communication can then involve subtle problems between design actors, who have different mental representations of design and design problem. Star (Star 1989) discusses the use of boundary objects as vehicles for communication between diverse groups with different skills and disciplines. Moreover, Vinck and Jeantet (Vinck and Jeantet 1995) suggest the concept of intermediary objects. In fact, intermediary objects act as boundary objects, but they are also intermediate states of the product, if we consider the object as mediators translating and representing the future product (Boujut and Blanco 2003). So, these objects enable to study how the product is developed, but also how it is influenced by these objects (Boujut and Eckert 2003). De Terssac (De Terssac 1996) defines the design activity as managing the intermediary objects.

On the other hand, a design problem is described as “*a problem of resolving tension between what is needed and what can be done (Conklin 2006)*”. The design process is then driven by some needs, which can be expressed by the customer or can be a quest about, what the market wants, and constrained by the resources such as time, money, laws of science, etc. (Conklin 2006). Ulrich and Eppinger (Ulrich and Eppinger 2004) express the product design process as “*the set of activities beginning with the perception of a market opportunity and ending in the production, sale, and delivery of a product*”.

Similarly, there are several models to represent the design process (Pahl et al. 2007, vol. 3; Hubka and Eder 1995; Roozenburg and Eekels 1995; N. Cross 2000; Ulrich and Eppinger 2004). For example, Ulrich and Eppinger present an integrated product development process as the sequences of steps, which a company follows to design and market a product. The model consists of six main steps: Planning, Concept Development, System-Level Design, Detail Design, Testing and Refinement and Production Ramp-up. In each of these steps, marketing, design, manufacturing carry out predefined tasks, and then their results are unified.

There are also many further design paradigms (e.g. seeing design as specifying an artifact that does possess certain positive affordances and does not possess certain negative affordances (Maier and Fadel 2008) or a series of activities that encourage or support divergent and convergent thinking (Jones 1992)) and design process models (e.g. (Andreasen and Hein 1987)). We cannot list them all here, which are valuable in different purposes. Instead, we discuss our understanding in design and design process.

Based on these different approaches, we understand the product design as a social and technical process that starts by defining what is needed in product and why, and finishes with determining how, which means the product itself. Then, the process covers the evolution of coordinated joint learning and working practices as well as intermediary objects that are instrumental in mediating, translating and representing the future product.

In this research study, we are more concerned with the early phases of the new product design process, which means the early stages of the concept development step. In the next section, we discuss further on concept development activity and argument why we focus more on it.

3. Concept Development

In engineering design, the concept development activity is defined as the step that “*the target market is identified, alternative product concepts are generated and evaluated, and one or more concepts are selected for further development and testing. A concept is a description of the form, function and features¹ of a product and is usually accompanied by a set of specifications, an analysis of competitive products, and an economic justification of the project (Ulrich and Eppinger 2004)*”. In this research study, we are more concerned with the early stages of the concept development activity: the product definition phase. This phase consists of the description of the target market, the product idea (its positioning in the market, competitive products, etc.), and the requirements with high-level specifications (Cooper 1996). The fundamental purpose of this phase is to gather right kinds of information in a way that allows the translation of user needs into a set of requirements.

It is commonly accepted that actions taken during the early stages of the concept development are critical to new product success (Cooper and Kleinschmidt 1987; Cooper 1996; Goldenberg et al. 2001). Cooper (Cooper 1996), who sought to identify the characteristics that have an effect on new product successes and failures, mentions that it is important to have a sharp product definition early in the development work. The author, based on his study of 203 industrial products, concluded that “*sharp, early product definition enhanced project success rates by 59.2 percentage points; such well-defined projects had 3.7 times the success rate and 1.6 times the market share as those which lacked definition; and product definition was significantly and strongly correlated with performance*”. Moreover, the 70% of the total life

¹ See appendix 1 for the differences between the terms “function”, “form” and “feature”.

cycle cost of a product is committed at the early design stages (Asiedu and Gu 1998), which also shows significant implications of the decisions taken in this stage.

Since the product definition phase is the main focus of this research, literature, describing requirement-elicitation, requirement-modelling and user consideration is further treated. In the next section, a literature review on requirement analysis is presented.

4. Requirement Analysis

As mentioned above, during the product definition user needs are formalized as requirements list. Then, requirement analysis is the process where the needs are elicited, clarified, and transformed into requirements. Leite ((Leite 1987), cited in (Christel and Kang 1992)) defines the requirement analysis process as “*a process in which what is to be done is elicited and modelled. This process has to deal with different viewpoints, and it uses a combination of methods, tools and actors. The product of this process is a model, from which a document, called requirements, is produced*”. Claros Salinas et al. (Claros Salinas et al. 2008) take a broader look and consider also the evolution of the requirements and the correlations between them throughout the process. Hence, they define four main activities related to requirements on a design process: **elicitation**, **formalization**, **propagation** and **correlation**. Elicitation consists of earliest activities in requirement analysis, which is the practice of gathering requirements. Many different techniques are used during this activity. Formalization is the action of setting requirements in a formal language to enable all stakeholders to express their own requirements, arguments and negotiate if necessary. The defined requirements are not constant that they evolve during the design process. The propagation activity is then the activity of determining the consequences of the modification or the decision made. Finally, the correlation deals with the relationship between the requirements at the same stage of the design process. The correlation activity is the identification of the nature of these relations. This activity provides designers with awareness of how changing one requirement will affect the other ones.

Since we focus on the early stages of the concept design, we work through only the requirement elicitation and requirement formalization activities. In the following, we start with defining what is meant by the terms user and requirement. Thereafter, requirement elicitation and formalization activities are described.

4.1. Who is the User?

Buur and Windum (Buur and Windum 1994) categorize two main groups of users: primary users and secondary users. The primary users use the product for their preliminary purposes e.g. the driver of the truck, while as the secondary users also actively use the product but not for their preliminary purposes e.g. maintenance and repair personnel. The primary users are also commonly labelled as end-users in the literature (e.g. (Kynig 1994)). We recognize similar categorizations in Claros Salinas et al.'s article (Claros Salinas et al. 2008) that the authors arrange the clients into two groups: internal clients and external clients. The external clients are those for whom the product is developed and the internal clients are the lifecycle stakeholders involved in the design process. From now on, the term **user** is used in a narrow sense to refer the primary users of the product and the term **stakeholders** in a broader sense to label both primary and secondary users.

The other issue with the term “user” is that during the production process of a new product, the users of the product are not well defined yet to be able to talk about them. Redstrom (Redström 2006) discusses this dilemma, which is the meaninglessness of talking about the usage and user of an inexistent product. He interprets that *“As a person turns to an object, inviting it to be a part of her life world, making it hers, she might decide to start using it for some purpose; and as she begins to use the object, she becomes a “user”.* The central role of the object in the definition of what a ‘user’ is comes from the fact that there cannot be users of the objects that do not exist”. Thus, we use the term **intended users** for the projected users of a product to be designed and the term **user** for the actual users of an existing product.

On the other hand, in the literature we currently come up against the term **customer** or **client** instead of user. The decision makers, in other words the buyers, of a product are not always the users themselves. We differentiate the terms customer/client and users in a way that, while the **customer/client** is the buyer or purchaser of the product, the **user** is the one, who experience it.

While many of the design teams gather the data from users, in some cases the lead users are also involved into the design process. Von Hippel (Von Hippel 1986) define lead users as *“the users of a given product or service type that combine two characteristics: 1) They expect attractive innovation-related benefits from a solution to their needs and so are motivated to innovate, and 2) they experience needs for a given innovation earlier than the majority of the target market”.* **Lead users** are then the users, who have a certain level of expertise on the

usage of the product and currently experience needs still unknown to the public, and who also benefit greatly if they obtain a solution to these needs.

Lastly, in some cases marketing people, experts, ethnographers, or user managers can make the user-contributions, who are labelled as **user proxy** in the literature (Hughes et al. 1993).

We can better explain those terms, which are an initial departure for defining the language of this thesis, through an example. Imagine that a design group works on a new product that will help library members to generate all their activities remotely. So, the library member is an intended user, the ethnographer who makes observation on library member is a user-proxy, the director of the library is a customer, people who already used similar product are lead users, and finally the maintenance man is a secondary user (see Figure 2).

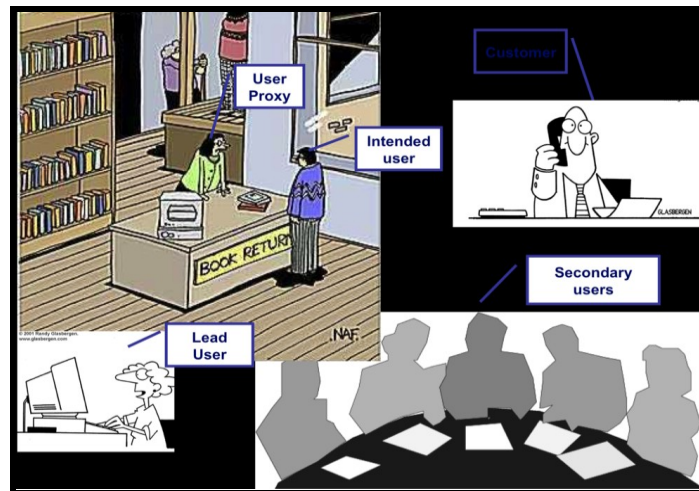


Figure 2: Who is the User?

As mentioned before, in concurrent engineering activities, the product and production development process are integrated and performed as much as possible in parallel rather than in sequence (Solhénus 1992). Thus, during the product definition activity, we assume that all stakeholders' needs are considered and studied. For the given example, the library members' needs are considered as well as the maintenance man. However, in this study we focus only on how intended users' needs are elicited for a new product, not all stakeholders.

4.2. What is a Requirement?

In the literature variety of definitions of requirements are discussed. IEEE (IEEE 1990) defines a requirement as “(1) A condition or capability needed by a user to solve a problem or achieve an objective, (2) A condition or capability that must be met or possessed by a system or

system component to satisfy a contract, standard, specification, or other formally imposed documents, or (3) A documented representation of a condition or capability as in 1 or 2". This definition can be reformulated as "something that the system must do, must have, or must satisfy, as determined by someone related to its development (Coulin 2007)". Similarly, Chakrabarti et al. (Chakrabarti et al. 2004) also define a requirement as "a characteristic, which a designer is expected to fulfil in the design solutions".

Based on these definitions, we can conclude that the requirements are described as something that the product has to satisfy, in order to sort out a design problem. However, this definition is not enough to differentiate the terms "needs" and "requirements", which are usually used interchangeably in the literature. For example, Cooper et al. ((Cooper et al. 2007) pp. 114) think of requirements as synonyms with human and business needs. Similarly, Claros Salinas et al. (Claros Salinas et al. 2008) uses the term requirements to identify the set of needs coming from users, and constraints mainly coming from secondary users. Eodice (Eodice 2000) draws attention to this confusion in his dissertation. To end up this complication, he describes the needs as "*early in the product development cycle, all the desires for the product fall into the category of needs*". While as, the needs become requirement when they are satisfied by the product, with his words: "*when a need becomes constituted, meaning that it has been incorporated into the final product, then, and only then, it becomes a requirement*".

After this brief review of requirements definitions, we derive our definition of *need* and *requirement*. We differentiate these terms based on Eodice's definitions. Since, in our case we are only focused in the early stages of the design process, it is not possible to check if the needs become requirements. Thus, we use the term requirement, when it is decided as "*going to be satisfied*" by the design group, and listed in the requirement document.

- *Needs: are the identified desires of the stakeholders (in this study we focus on the intended users' desires)*

- *Requirements: are the needs decided by design group to be satisfied in the design solutions and listed in the requirement document*

4.3. What is Requirement Elicitation?

Requirement elicitation is the process of discovering, understanding and communicating the needs, agreeing on the ones that are going to be satisfied and listing them in the requirement document. It consists of the earliest activities in the requirement analysis process. These activities might be accepted as the responsibility of market team (which is generally the case for

the big companies), or the design team, or a mixed team. Cooper et al. (Cooper et al. 2007) pp. 16) highlights the difficulty of translating and synthesizing the requirements into design solutions in the case that requirements are listed by the market team and transferred to the design team. He underlines the importance of integrating the design actors to the user research. We support his idea that the design actors have to be involved in the requirement elicitation process. In the following, we discuss the difficulties that have to be dealt with during requirement elicitation activity.

4.4. Why Requirements Elicitation is Difficult?

Christel and Kang (Christel and Kang 1992) list three main categories of requirement elicitation problems:

- *« **problems of scope** : the boundary of the system is ill-defined, unnecessary design information may be given*
- ***problems of understanding** : users have incomplete understanding of their needs, users have poor understanding of computer capabilities and limitations, analysts have poor knowledge of problem domain, user and analyst speak different languages, ease of omitting “obvious” information, conflicting views of different users, requirements are often vague and untestable, e.g., “user friendly” and “robust”*
- ***problems of volatility** : requirements evolve over time »*

The problem of ill definition (ill-structured with Simon’s terms (Simon 1984)) of the design problems is already highlighted in the literature (D’Astous et al. 2004; Conklin 2006). One of the characteristics of the ill definition listed by D’Astous et al. (2004) is that the product specifications given at the beginning are never complete or without ambiguity. Conflicting constraints also play an important role. On the other hand, the last category draws attention on the iterative nature of the requirement analysis process. In contrast with the traditional linear and sequential models that separate problem and solution spaces (e.g. waterfall model), requirements and solutions are recently considered to evolve iteratively (McGinnis and Ullman 1992; Conklin 2006; Longchamp et al. 2006). Then, the requirement list has to be checked and reformed continuously to avoid the solutions that are not adequate.

In this research work, we focus on the second category, which we propose to handle under two sub-categories: problem of understanding between design actors and problem of understanding users' needs.

4.4.1. Problem of Understanding between Design Actors

Cooper and Kleinschmidt (Cooper and Kleinschmidt 1993) underline that for the product success, during the product definition phase there must be an agreement on: 1) the target market, 2) the customers' needs, wants, and preferences² 3) the product concept and 4) product's attributes, features, specifications, and requirements³. However, it is an inevitable natural occurrence that there are conflicts between design actors in the way they interpret the users and their needs. Then, the design actors have to clarify their conflicts and negotiate on a common understanding.

In the literature, this process is referred to as a framing cycle that consists of making individuals' frames explicit, making frame conflicts salient, and building a common frame (Hey et al. 2007). The frames are defined as "*structures of belief, perception and appreciation* (Schön and Rein 1995)" that guide one's way of viewing a problem and attempting to solve it (Stumpf and McDonnell 2002). Stumpf and McDonnell claim that: "*the team's interaction to share frames provides a legitimate indication of the quality of team processes*". In this research work, this framing cycle is detailed into two sub-sections: 1) perspective clarification, where the frames are explicated, thereby conflicts and 2) convergence: which is building a common frame.

a. Perspective clarification

As mentioned above, it is important that design actors externalize and communicate their frames. In the literature, the creation of the common ground is reasoned to improve the effectiveness of the communication. The notion of common ground represents the knowledge that actors have in common and they are aware of this uniformity (Clark and Brennan 1991). Clark and Brennan state that effective communication requires grounding activity. The grounding activity helps design actors to co-create the shared representation of the current situation of the problem, solutions, etc. Visser (Visser 2006) also underlines the importance of creating a common ground during the co-designing activity, with her words: "*It is then essential*

² Some authors prefer to make the differentiation between the words "needs" and "wishes". While the needs are categorized as "must be met" by the product, wishes are viewed as "optional" (Pahl et al. 2007). In this research study, we use the term "need" in a broader sense to cover them both, which means all the desires of the stakeholders.

³ The terms "requirements" and "specifications" are differentiated in section 4.5.2

that designers who each also have their personal perspective⁴, establish a common ground”. Then, the design actors can create shared⁵ representations, which are the “concern agreements, especially on the definition of tasks, states of the design, references of central notions, and weights of criteria and constraints”.

Different mediums of communication may be used for accomplishing this purpose, such as, conversation, sketching etc. For example, in conversation, the aim is to ensure that what has been said has been also understood. Creation of a common vocabulary can greatly improve perspective clarification within the team (Dong 2005). Conklin et al. (Conklin et al. 2003), pp.14 argue that shared displays are also beneficial to clarify the disagreements in a group: *“When ideas and concerns are mediated via a shared display, challenges to positions assume a more neutral, less personal tone. It helps participants clarify the nature of their disagreement”.*

b. Convergence

It is probably inevitable that there are disagreements within a design team. Positively, the divergence of opinions can stimulate creative ideas and solutions to the problems (Chen 2006). The task conflicts can enforce team members to realize deeper analysis, which can increase learning and development of new and creative insights, and lead team to be more creative (De Dreu and Weingart 2003). However, when the conflicts are not managed effectively, they can slow decision-making and keep members away from concentrating on the real task. They can also increase tension between team members, and cause interpersonal conflicts that can be detrimental to the creativity process (Chen 2006). Thus, a design team, which desires to reach an acceptable conclusion to their design task, has to find ways of resolving, or perhaps avoiding their conflicts (Cross and Cross 1995).

As a traditional point of view, generally accepted opinions are chosen through negotiation. The notion of a negotiation describes the way that the design actors reach agreement, which is based on argumentation (Détienne, 2006). With argumentation, designers try to *“convince themselves and their peers of the sense and validity of a particular solution, or of the necessity to respect a particular constraint related to the problem”* (Prudhomme et al. 2007). As Détienne mentions, negotiation does not force a person to accept an argument but the conversation, which covers the arguments for and against a frame, makes it possible to get an

⁴ The author uses the term to focus on the fact that different designers may have constructed different representations of the “same” entity (artefact or other), and that in their representation of the “same” entity, different aspects (attributes) may receive different weights.

⁵ The author prefers to use the term « inter-designer compatible representations » instead of « shared », by following (Von Glasersfeld, 1981)

agreement. On the other hand, creation of shared value between the design actors can help them to converge through common frames. Snowden (Snowden 1999) argues that having shared values within a team enables consistent actions in the face of uncertainty.

4.4.2. Problem of Understanding Intended Users' Needs

In the literature, it is commonly accepted that the effective requirement elicitation requires increased contact and involvement with users (Gruner and Homburg 2000). Thus, more support is needed for user involvement and facilitating the user-designer communication (Coughlan and Macredie 2002; Saiedian and Dale 2000).

Many different approaches and techniques are discussed in the literature, whose aim is to involve users during the requirement elicitation activity. However, in the early stages of the new product design process, since the final product does not yet exist, it is not always easy to define the intended users. Thus, the intended users are not defined sufficiently well enough to clearly identify their needs or for them to be involved in the design process. Similarly, their observation in their work place is not possible.

On the other hand, even in the case that intended users are involved in the process, there are communication difficulties between users and design actors. One of the reasons is that users and design actors do not use common languages. Since they do not have same level of technological knowledge, the terms that are used by design actors might be so complicated to be understood by the users (Erickson 1995). Secondly, they have different problem perspectives (Saiedian and Dale 2000). While design actors are more interested with technical capabilities, the users are more concerned about the work experiences. Finally, users might be express too vague needs that are difficult to evaluate, whether they are satisfied by the product. In the next section, we discuss how the requirement can be formalized in requirement analysis.

4.5. Formalization of the requirements

As discussed above, the needs are defined, clarified, understood and listed during the elicitation activity. The formalization is the activity of structuring the requirements in a formal language. Ulrich and Eppinger (Ulrich and Eppinger 2004), pp. 72 mention that when the requirements are listed in the language of the user, they don't guide enough the next steps: *"However, while such expressions are helpful in developing a clear sense of the issues of interest to the customers, they provide little specific guidance about how to design and engineer the product"*. Thus, during the formalization activity the requirements are transformed to a formal language.

Functional analysis is one of those techniques that might be used to get such a standard language, enabling designers to share their frames about the requirements. We present this technique in the followings. Before the presentation of this technique, a brief description of what is a function is also given.

4.5.1. What is a Function?

In engineering design, there are different ways of understanding functions. Varmaas (Vermaas 2009) focus on his study on these different approaches, and discusses three main ways that the concept of function can refer to:

1) **Desired behaviour of the product:** For example, in Stone and Wood's product definition (Stone and Wood 2000), the functions refer to the operations on flows of materials, energies and signals. It is assumed that functions have both input and output flows. Their examples include a power screwdriver whose function is listed as "loosen/tighten screws" and which transforms electricity and human force flows into other energy flows: torque, noise, heat etc.

2) **Desired effects of the product behaviour:** For example, in Lind's product definition approach, the concept of function is used with the meaning of desired effect (Lind 1994). For an automobile seat, these effects can be listed as "support head", "dampen vibration", etc. (Hirtz et al. 2002).

3) **Goals of the users:** According to Gero's FBS (Function, Behavior, Structure) model (Gero and Kannengiesser 2004), functions can refer both to the intentional goals of users and to the effect of the behaviour of the product. It answers to the question, what the product is for. For a window they list some functions as, "providing view" and "controlling noise". Varmaas argues that while the first one is more related to user goals, the second one refers more to the effect of behaviour of the window.

As we can notice from the given examples, functions are commonly represented as verb-object expressions. We also adopt this grammatical structure. In terms of the function concept definition, our approach fits into the second concept. On the one hand, the behaviour of the product is related to its structure, which means the components of the product and their relationship. However, in product definition phase the product structure is not defined yet. For the power screwdriver example, to define the electricity flow, first we have to define that the product will work with electricity. On the other hand, in this study the users' goals are more related to elicitation of user needs, not to formalization. Thus, our understanding on functions is that they are the desired effects of the product behaviour.

4.5.2. Functional Analysis

Functional analysis has taken its place in engineering design through Value Engineering, dating back to the 1940s (Miles 1972). Conceptualizing, defining or understanding an artifact, product or system, in terms of functions is accepted as a crucial aspect of engineering design (Pahl et al. 2007, vol. 3; Ullman 1997; Ulrich and Eppinger 2004).

In functional analysis the requirements are expressed in terms of the product functions. On the other hand, the performances expected to fulfil the functions, in other words the constraints, are defined by assessment criteria and levels, which are called in the literature as product specifications (Ulrich and Eppinger 2004). The assessment criteria are the criteria used for appreciating the way that a function is accomplished and the levels that are used for the adopted scale to these criteria. One function may have several assessment criteria. The set of functions, assessment criteria, and levels are named *functional requirements*. The list of the functional requirements constitutes a main part of the product definition document.

Listing the essential functional requirements of the product leaves the designer free to develop alternative solutions that satisfy these requirements. For example, one of the needs expressed by the user for a bike lock might be “I want to keep my bike in safe against robbers”. Then, the product function should be interpreted as “to resist to robbers’ attack”. The constraints are the restrictions, limits or regulations imposed on the product. For the same example one of the criteria might be “the necessary time to failure” and the level might be “more than 5mn”. Another criterion might be its resistance to a human force and the corresponding level might be expressed as more than 500N. In that way, a standard language is built to enable designers to share their viewpoints about user requirements and constraints.

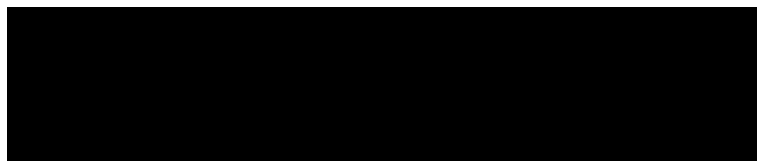


Table 1: Functional requirements of a bike lock

Functional analysis focuses on what has to be achieved by a new design and not on the solutions. Cooper et al. (Cooper et al. 2007), pp. 114 argues that confusing *what* and *how* questions can be one of the biggest pitfalls in the design of a product. They highlight that “*it runs the risk of turning into a never-ending circle of iteration; proposing a solution without clearly defining and agreeing upon the problem leaves you without a clear method of evaluating the fitness of design*”. Similarly, Ulrich and Eppinger state that “*product specifications do not tell the team how to address the customer needs, but they do represent an unambiguous agreement*”

on what the team will attempt to achieve in order to satisfy the customer needs". Hence, the functional analysis is a support to better identify the user needs, instead of focusing on solutions, to increase their satisfaction with the lowest cost (see Figure 3). However, oppositely to these assumptions requirements and solutions are accepted by many researchers to be interrelated and to co-evolve during the design process (McGinnis and Ullman, 1992; Concklin, 2006; Lonchamp et al. 2006). Moreover, Dorst and Cross, based on an empirical study on industrial engineers, argue that this co-evolution reinforce the creativity (Dorst and Cross 2001).

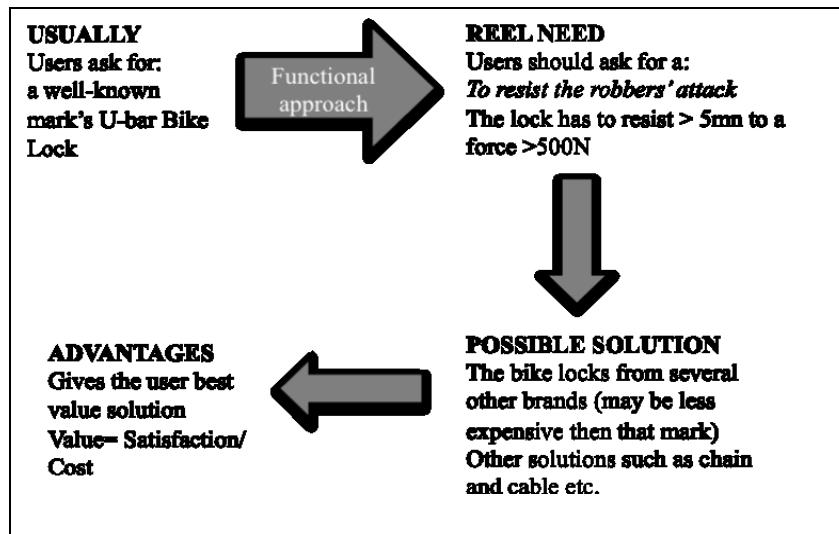


Figure 3: Functional Approach

Another shortcoming of this formalization is that non-functional requirements, such as usability, maintainability, reliability and other qualities, which are hard to model and to make them measurable, are not taken into account. However, non-functional requirements are the qualities that the product must have (Robertson and Robertson 1999). Cooper et al. also underline that even if a relationship clearly exists between requirements and functions, they are not synonymous (Cooper et al. 2007, pp. 122). He argues that non-functional requirements have to be also taken into account during design process.

The issues of co-evolution of functions and solutions, and also consideration of non-functional requirements stay open questions in functional analysis method that needs to be debated in a broader sense, which is not in the scope of this study. It is assumed in this study that the functional analysis is a formal language to formalize the defined intended user requirements in terms of the product functions that can be communicated easily between the design actors, and that can be checked to avoid solutions that does not match with them.

In the next section, we will discuss the design approaches and methods that consider the user issues, since the early stages of the design.

5. Approaches that Consider Users in Product Design

In the design process it is important to involve users to learn about their needs. One of the main subjects for the users' involvement in the design process is the frequency of their integration and their activity level. In other words, whether they are involved occasionally or continuously and whether they have an active or passive role in the process. Kaulio (Kaulio 1998) defines three degrees of user involvement in design process: design *for* users, design *with* users and design *by* users. User-centered Design makes the user issues central in the design process and focuses on defining users and analysing their work situation, while as Participatory Design approach assumes that the users themselves are in the best position to determine how to improve their work and their work life. Thus, it involves users in co-creation. On the other hand, some design approaches accept the users as designers. In the following, some of these approaches are discussed in more details.

5.1. User-centred Design

In the early 1970s Scandinavian and North American researchers brought together collaborative practices and product development (e.g. (King et al. 1994)). They adopt an approach that forces:

- Long-term commitment of particular users to the product design process,
- Empathy and deep understanding of the users,
- Much more attention on users' values, fears, aspirations, etc.

Norman (Norman 2002, pp. 188) defines User-centered Design (UCD) as “*a philosophy based on the needs and interests of the user, with an emphasis on making products usable and understandable*”. Thus, the approach allows users to express their needs, state their preferences, contribute their know-how, and share their ideas about the product with designers (Vredenburg et al. 2002).

User-centered Design indicates the necessity to focus on the users, which can be ensured by making the user issues central in the design process. However, Participatory Design (PD) involves users in co-creation.

5.2. Participatory Design

Participatory Design (PD) assumes that the users themselves are in the best position to determine how to improve their work and their work life (Schuler and Namioka 1993). In PD, not only users are source of information, but also they are involved in the decision-making process (Sanoff 2000).

The designers have knowledge on new technologies; in contrast the users often have a poor understanding of the capabilities and limitations of technologies, but they are experts on their work domain, which gives complementary information for the product design. As discussed in section 4.4, the designers and users with different interests have difficulties to understand each other. Unlike, the designers, who concentrate on the product structure and the technologies adapted, users are interested in how they can use the product and adapt it to their work place. As Go et al. mention the success of the PD mainly depends on how designers collaborate and cooperate with users (Go et al. 2000). Erickson (Erickson 1995) underlines the importance of communication between users and designers. He argues that in order to bridge the gaps, the design group needs to share a common language with the users.

5.3. Users as Designers

Some design approaches do not focus on understanding the user needs and proposing products that fit on their attending. Instead users themselves play the role of the designers. Von Hippel and Katz (Von Hippel and Katz 2002) propose toolkits for user innovation. The toolkits are the user-friendly design tools that the users are equipped with to develop new product innovation for themselves.

Similarly, web-based crowdsourcing platforms, enable their users to invent, design and manufacture future products collectively. The term Crowdsourcing⁶ refers to the act of taking a job traditionally performed by a designated agent and outsourcing it to an undefined, generally large group of people in the form of an open call. Crowdsipirit⁷ is one of those platforms (see also Cambrian House and Kluster), whose aim is to improve the ability of users to innovate for them selves. It encourages users to participate in an open innovation process, to inspire their creativity, and to increase the quality of the submissions. The users have different types of participation, e.g. users as analysts, users as prototype designers, users as manufacturers, etc.

⁶ The word Crowdsipirit was first coined by Jeff Howe in Wired Magazine (June 2006). The definition is taken from wikipedia.

⁷ www.crowdsipirit.com

Hence, the innovative ideas and solutions are accessed from users. However, if the benefits of such a designing platform may be undeniable, the practical implementation may raise some difficulties, limiting the efficiency of the resulting design process. Thus, regarding the CrowdSpirit platform, some users report some difficulties to have convergence of the community toward technical solution requirements. We conducted a detailed analysis on the corpus of the one product idea on the platform to define the ongoing obstacles (Arikoglu et al. 2008). The results of the two-level analysis (global and detailed) showed that there are four main weaknesses of the current platform: lack of a shared vision of the needs, lack of social regulation mechanisms, lack of decision-making mechanisms and lack of mutual awareness.

5.4. Scenario-based Design and Personas

The terms user profile, persona and scenario are often confused to each other. Courage and Baxter (Courage and Baxter 2005) differentiated these terms according to three criteria: their definition, purpose and the content. Table 2 summarizes the way that these terms are distinguished.

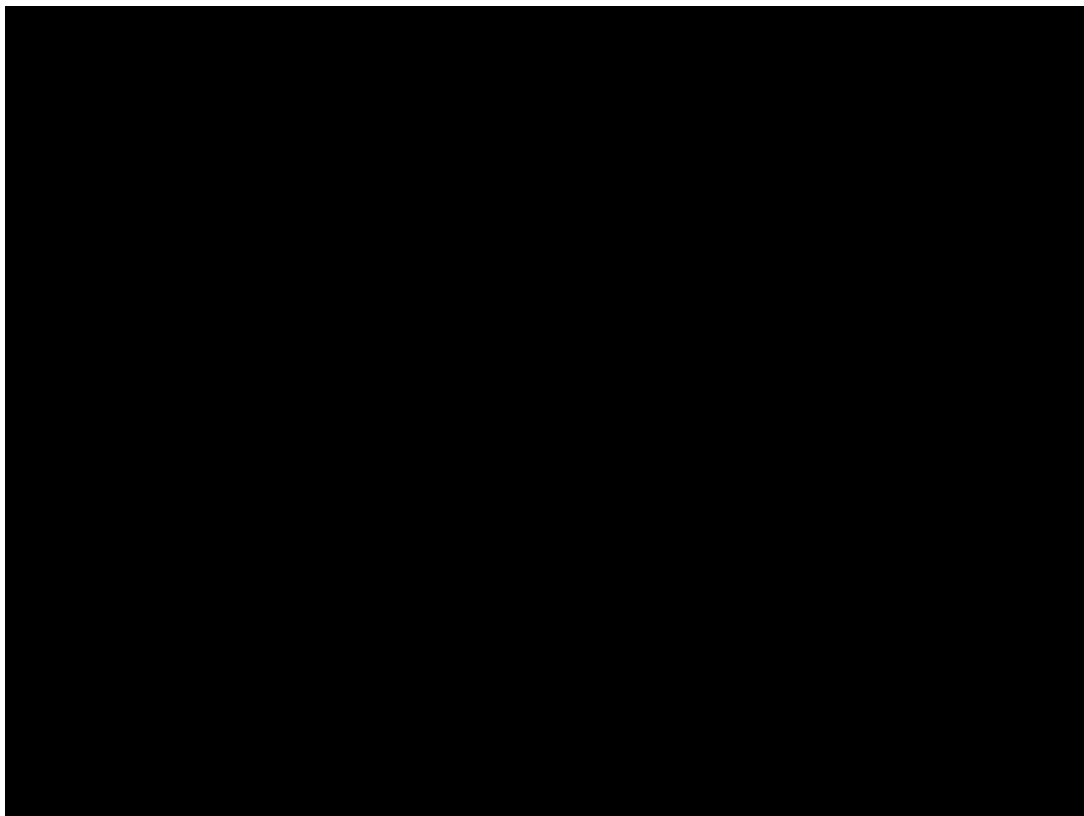


Table 2: Comparison of User Profiles, Personas and Scenarios (Courage et Baxter 2005)

User profiles are described as the detailed description of user attributes (e.g. job title, age range, level of education, etc.), whereas personas are representative user archetypes. The aim of the user profile description is to create awareness within the design group about the user. Courage and Baxter mention that user profiles create a basis for persona creation. Differently from user profiles, personas represent a group of users and keep them the main focus of the design actors during the process.

On the other hand, the scenarios are described as the stories about users and their activities (Carroll 2000). They are more focused on action of the users rather than their character development. Courage and Baxter point it out that once personas have been constructed and then scenarios can be constructed around them. Personas are claimed to improve the power of scenarios, likewise, scenarios are accepted as essential elements to complete personas (Pruitt and Grudin 2002). However, Grudin and Pruitt (Pruitt and Grudin 2002) argue that even if the scenarios are constructed around the personas, the personas come first.

Scenario-based Design (SBD) envisages integrating scenarios to provide the possibility to consider the user experiences early in the design process. In other words, scenario building provides to predict how people can act in particular situations. That is why they are well suited for designing new product concepts, when the context of use and the intended users are not strictly defined (Heinila et al. 2005). They are considered as representations accessible both to the design actors and intended users, which make the communication more effective (Carroll 1995, pp. 11). On the other hand, persona approach underlines the fact that all users are not the same. Thus, personas are used to help design actors to imagine intended users and their characteristics (Cooper 1999).

We can conclude that, the scenario-based design and persona approaches are promising to handle with above-mentioned obstacles. A deeper analysis of the literature about their usage in design process is needed to deduce a better conclusion. Thus, these approaches, which are the heart of our work, will be the focus of the next chapter.

In this section, we gave a brief review on different approaches that consider users' issues central for the design process. In the next section, the techniques that are adopted by the discussed approaches to elicit requirements are expanded.

6. Techniques to Elicit the Requirements

The focus of many design methods/techniques⁸ is to elicit user requirements quickly, cheaply and interactively. The techniques mostly used, such as focus groups and interviews, are based on inquiring the users about their needs. However, it is commonly accepted that asking the users is easy to perform, but figuring out what they really want is not a simple job (Leonard and Rayport 1997). Respondents have tendency to please the inquirer with their answers and hide the aspects that they judge embarrassing and inappropriate. Fuller and Matzler (Füller and Matzler 2007) group the user requirements into three categories: basic factors, performance factors, and excitement factors. Basic factors are the requirements that are absolutely expected and considered as prerequisite for the product. However, when the users are asked, they do not express them. Performance factors are the requirements, which are explicitly demanded and their levels are compared with the offerings of the competitors. Finally, the excitement factors are the requirements that are neither expressed nor expected. They are the requirements that the user cannot imagine, because they have not experienced before or they do not know about. However, their existence will surprise and create pure excitement, which will influence the users' preferences.

Thus, the approaches like PD focus on techniques such as workshops that raise the level of user participation to the design process in order to understand their real needs, instead of inquiring them. However, the designers generally work under time pressure, which makes it difficult to access users to get data or integrate them to the design process. Even for contract projects it may be difficult to gain access to a client who is busy or at distance. Additionally, the difficulty of communication arises between the design actors and the users, which results from the difference in the language used (formal, informal, technical, natural, etc.), the differences in background and experience level and also the difficulty in formalizing the huge and unstructured information gathered through users (Christel and Kang 1992). On the other hand, Ulwick (Ulwick 2002) highlights that the users should not be trusted to come up with solutions. The main reason is that they only know about their early experiences. Henry Ford's, who was the American founder of the Ford Motor Company, famous quotation also supports that assumption: "If I had asked people what they wanted, they would have said faster horses". Ulwick argues that users cannot imagine what they do not know about; e.g. emergent technologies, new materials, etc. Thus, by asking the users the company risks making incremental improvements instead of creative and new products, which give an opportunity for

⁸ Note that in this research project the terms methods and techniques are used interchangeably.

the competitors. The users also might ask for the missing features that the competitors already offered. The addition of these features will not bring any advantage to the company. Thus, the author proposes, rather than asking the users for solutions, to ask them to focus on desired outcomes of the product. In *Innovator's Dilemma* Christensen (Christensen 1997) also points out how keeping close to the customers arose fatal outcomes in some disk drive industry companies.

On the other hand, Lilien et al. (Lilien et al. 2002) argue that lead users are better situated to envision novel needs and solutions, because they are living in the future in terms of the product or system experience. Based on the natural experience conducted within a 3M company, the authors conclude that in the idea generation process, the lead users augmented the innovation capabilities of the company. Nevertheless, Ulwick (Ulwick 2002) argues that listening the lead users, so-called highly innovative users, often causes the company to create so sophisticated products that do not address to the majority of the users.

Furthermore, the techniques based on observation of the users, focus on the way the users use the product to identify hidden needs. The observers might be passive while observing or, might also work side-by-side with a customer to understand also what he/she feels while working. In order to understand the thoughts of the users protocol analysis might be used, which charges the participants to realize a task and talk aloud to describe their thoughts throughout the process (Goguen and Linde 1993). Contextual inquiry (Beyer and Holtzblatt 1998) mixes the inquiry and observation approaches by conducting the interviews with users in their workplace to discover the obstacles they manage while working. Discourse analysis can also be practiced on the observed situations, where there is a social interaction (Goguen and Linde 1993). These methods are powerful to identify tacit knowledge that neither the users are not aware of. One of the limitations of these techniques is that they are time consuming and have to be done by skilled people. Another limitation is that they are only applicable to existing products.

Another commonly used technique is the introspection, where designers put themselves at the place of the users (Goguen and Linde, 93). They imagine which kind of product they would ask for, if they were doing this task. This technique can be helpful, but the designers are not always the best representatives of the actual or intended users. The techniques like 5WH (Who, What, When, Why, Where, How) can help designers to better imagine for whom they are designing for. Moreover, new methods and approaches emerged that try to gather insides on perspectives and motivations of the users. As mentioned in the previous section, scenarios and personas, which are becoming more and more popular in system and software engineering,

focus on obtaining insights about the social and personal aspects of their interaction with the system. Designers then derive the characteristics that are important to them.

To conclude, every technique has some benefices and limitations to elicit users' requirements (Goguen and Linde, 93; Coulin, 07), their strengths and weakness need to be considered, so that the mix of various methods can be successfully applied to a particular situation. In this study we focus on scenarios and personas, which are the techniques that are the heart of scenarios-based design and persona approaches.

7. Concluding Remarks

As a brief review, the main focus of this study is the new product definition phase, where the intended users are imagined and their needs are elicited. Once the design group decide on which needs are going to be satisfied, then the requirements are formalized in the form of functional requirements. Two main obstacles that have to be treated in requirement elicitation activity are presented:

- How to understand the intended user needs?
- How to ensure shared understanding between design actors?

As a response to these questions, the approaches that consider the users early in the design process are presented. Our assumption is that among these approaches, scenario based design and persona approach can be effective to respond to these questions. Therefore, the next chapter will present a detailed literature review on these two approaches, their mentioned strengths and shortcomings, and why they are chosen for this study.

Chapter 3 Scenario-based Design and Personas

This chapter starts with a brief discussion on the terms: user profile, scenario and persona. Then, it gives the detailed literature reviews on scenario-based design and persona approaches, which are the real interest of this research work.

1. Introduction

In this chapter, we focus on the real interest of this research work: scenario-based design and persona approaches. In scenario-based design, first of all we detail what we mean by scenarios. Secondly, we discuss scenario lifecycle under two sub-categories: scenario building and scenario usage. Finally, the scenario-based design framework adopted for this research study is presented. We follow the same structure for the persona approach, in which we explain its lifecycle under two sub-sections: persona building and persona usage. In the last section, some limitations of scenario and persona usages in design are also discussed.

2. Scenario-Based Design

In this section, first of all we describe what we mean by scenario. Thereafter, the scenarios lifecycle is discussed under two main categories, the way they are built and the way they are used in design process. Finally, the adopted scenario-based design framework for this research project is presented.

2.1. Anecdotes and Scenarios

The terms stories, anecdotes and scenarios are generally used for one another in the literature. In design, the most common definition adapted for “scenarios” is the Carroll’s (Carroll 2000) definition that they “are stories about people and their activities”. On the other hand, anecdotes are described in the literature as “*naturally occurring factual narratives that may not contain goals or plots but simply come into existence as a part of daily activity*” (Eng et al. 2008). Snowden (Snowden 2000) considers the difference between an anecdote and a story as similar with the difference between a blink and a wink that the first one just occurs, while the other one has an intention. With his words: “*anecdote is a naturally occurring story. It may be*

captured in conversation, virtually or in a workshop or wherever. It may be fact, faction or fiction. In contrast a story has been purposefully constructed”.

In this project, we adapt the Carroll’s definition of scenario, with the precision that they are constructed consciously. The term anecdotes are used for the stories that are experienced, heard or read by the designers, and told by them in conversation instantaneously.

2.2. Scenario Building

In this section, we focus on how the scenarios are created during the design process. Scenario building is discussed under two sub-sections: the form and the content of scenarios.

2.2.1. The Form of Scenarios

In this section, we focus on the elements of the scenarios that are considered for scenario building and the media used for their representation.

a. Scenario elements

When the term scenario is pronounced, the first thing comes to mind is the cinema. The term is adopted from Italian *scenarii* that refers to the scene of the theatre. In cinema, what is shown in a movie by images and voice are described in scenarios by words (Roche and Taranger 2001). Carroll (Carroll 2000) points out that each scenario includes setting, agents/actors who have specific goals/objectives and sequences of action and events. Similarly, Bodker and Christiansen (Bodker and Christiansen 1997) state that the scenarios might be created on the lights of some considering:

- *“what is done: product of activity from the point of view of the organisation and from the point of view of the different groups of involved actors*
- *where: situating the activity system including artifacts*
- *by whom and when: working division of the labour and the order according to which the activity is carried out*
- *by what means: the role of the artifacts: position in division of labour, tool*
- *in what way: the underlying culture, norms and values”*

Carroll (Carroll 1995) also mentions that in scenarios the focus of the scenarios is on the user, what the user does, what the user perceives, what it means to the user. So, in scenarios the actors of the scenarios, the answer of the question by whom, refer to the users and people in interaction with them, around whom the scenarios are constructed. In the literature, scenario actors are defined in different ways. Some researchers prefer to use vague definitions (e.g. just a name or the profession). However, the others give more details. Already known characters like as book or film characters are also used. In this study, four main ways that the actors are represented in scenarios are defined: in a limited way, by design actors, by already known characters and by personas. In the following, they are discussed in detail and in the discussion part they are compared to one another.

- **Representing the user in a limited way:**

In this kind of representation, the user profile is represented in a very limited way that “*he/she can be anyone or actually no one* (Nielsen, 2002)”. For example in Carroll’s scenarios we do not see the detailed description of the users, generally just a name or the job description. In use cases, the users are also represented in a limited way. In Regnell et al (Regnell et al. 1995)’s ATM (Automated Teller Machine) system example, the users are defined as ATM user that there is not a detailed description of who they are.

- **Designers as users:**

Designers have also tendency to put themselves in the role of the users (Buur and Windum 1994). As a result of this the actors or the people around them might be the actors of the scenarios (e.g. I, my son, we).

- **Using already known characters:**

Blythe and Wright (Blythe and Wright 2006) support the idea of using already known literary characters as the actors of scenarios. For example, they have used Bridget Jones (main woman character in Fielding’s book (Fielding 1999)) as the user of the product in one of their projects.

- **Personas:**

Cooper’s personas, which are representative user archetypes, might be used as the actors of scenarios (Cooper 1999). They are fictional people who have names, details, and goals.

- **Discussion on the different ways of representing users in scenarios**

Representing the users in a limited way, gives flexibility as well as complexity. On the one hand, designers are more open-minded and think about all possible user profiles; on the other hand the decision-making process is more difficult. Perfetti (Perfetti 2001) states that “*by trying to satisfy the needs of all users, designers often fail to satisfy the needs of any one user*”. Nielsen (Nielsen 2002) also argues that the users in scenarios should be described in depth in order to make them believable. Moreover, Pruitt and Grudin (Pruitt and Grudin 2002) argue that the scenarios are less engaging and difficult to memorize when not built on personas. Similarly, Cooper et al. ((Cooper et al. 2007), page-111) also list the shortcomings of representing the user in a limited way:

- *“Carroll’s concept of the actor as an abstracted, role-oriented model is not sufficiently concrete to provide understanding of or empathy with users. It is impossible to design appropriate behaviors for a system without understanding the users of the system in specific detail.*
- *Carroll’s scenarios jump too quickly to the elaboration of tasks without considering the user’s goal and motivations that drive and filter these tasks. Although Carroll does briefly discuss goals, he refers only to goals of the scenario. These goals are circularly defined as the completion of specific tasks. In our experience, user goals must be considered before user tasks can be identified and prioritized. Without addressing the motivation of human behavior, high-level product definition can be difficult and misguided.”*

However, Blythe and Wright (Blythe and Wright 2006) suppose that the “*persona created in the scenarios lacks the depth, personality, history and cultural context that characters in novels seem to possess*”. The authors claim that the usage of already familiar characters will help to “*share a rich understanding of character-user and use context*”. However, one of the risks of using already known characters is that project members may have variant level of knowledge on already known characters. In Bridget Jones example, the design actor who has just read the book and who has also seen the movie adapted from the book might have different vision of the same character. Another inconvenient of using the known character is that people might have different literature culture especially in the international groups. In that case, the used characters might be unknown to some design actors, while as being familiar to others. To prevent this inconvenient, the authors suppose that the characters of the global

culture, such as Simpsons (famous cartoon characters who are commonly known almost all over the world) might be used. However, this doesn't eliminate the risk that they might have different level of understanding on characters and comment them contrarily.

On the other hand, in the case that the design actors represent the users by themselves, they might design so complex products that will be difficult to use and understand for the real users. This brings the subject of the differences between the "naïve user" and "expert user" needs. Cooper et al. (Cooper et al. 2007) also highlight that the users with different experience levels, - beginners, intermediates and experts, might have different requirements from the product. Products designed for the experts will be so complicated to learn and use for non-experts while as the easy to use products designed for non-experts will be embarrassing for the experts.

Hence, in this research project, we defend the idea that the intended users should be represented by personas in scenarios. Persona approach is detailed in section 3.

b. Different medias used to represent scenarios

The term media refers the way the scenarios are represented to their users. In other words, the media used for the description of scenarios. In this study, in total four main types of media are categorized: textual, storyboard, theatrical and video recordings.

- **Textual format**

Textual scenarios are narrative written representations of the scenarios. Anggreeni and Van der Voort (Anggreeni and van der Voort 2008) argue that: *"the diverse media of representation is only a way to visualize and communicate the scenarios, yet the basic form of scenarios, similar to stories, is always the narratives"*. Textual scenarios might be written in free natural language as reasoned by Carroll (Carroll 2000), that there is not a formal procedure for their creation and use. On the other hand, more formal texts structure might also be chosen, in which there are clear sequences of actions. In formal texts, the alternatives are separated from normal ones. For example, Glinz (Glinz 2000) proposes the usage of structuring constructs (such as if, go to step, terminate, etc) for alternatives and iterations. In his scenarios, there is also clear distinction between user actions and system responses to draw a borderline between a system and its environment. Similarly, Potts et al. (Potts et al. 1994) use tabular representation, in which they represent the scenarios as temporal sequences of actions together with the actors (or system) who executes these actions. Use Cases might also be categorized as formal texts. They are generally used in software engineering and system engineering. In system engineering,

use case is defined “as a way to use the system” (Jacobson 1995). So, the ensemble of the use cases of a system represents everything that actors can do with the system (Jacobson 1995). Alternatives and iterations are also defined. For example, in Regnell et al.’s (Regnell et al. 1995) use case description, the uses cases are a flow of events and conditions in a textual format.

- **Storyboards**

Storyboards are cohesion of the visual forms (such as sketches, photos, screen shots, etc.), which might also be combined with words. They may be rough and sketchy or more detailed. While the sketchy ones provoke the comments and suggestions, the detailed ones risk to be accepted as it is (Van der Lelie 2006). McQuaid et al. (McQuaid et al. 2003) use the direct-experience storyboards on a redesign project of a public library. The experts acted as users and experience the users’ tasks. During their experiences they took the pictures or screenshots of the library environment and they used them to take notes about their impressions. Then, those pictures were used for creating the storyboards of each specialist’s experience. We also see the same approach in the design firm IDEO’s hospital facilities improvement project (Hawthorne 2002), during which the researchers acted as a patient in the hospital and took notes about their experiences on the taken pictures to construct scenarios. Similarly, Pedella and Vetere (Pedell and Vetere 2005a) use picture scenarios⁹ which are the pictures taken based on a created scenario and completed by the textual elements, while designing mobile information device.

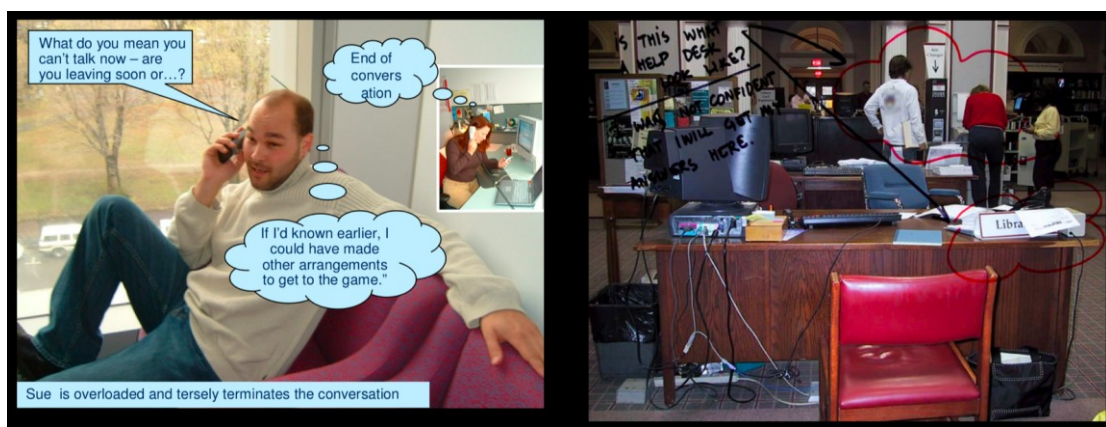


Figure 4: Storyboards respectively taken from (Pedell and Vetere 2005b) and (Hawthorne 2002),

- **Theatre techniques**

⁹ Even if the authors underline the differences between picture scenarios and storyboards, in this thesis picture scenarios are categorized as storyboards. Because, the term storyboard refers in this project the media composed of visual forms with (or without) words for the scenarios representation (the context is not considered).

The scenarios might also be represented with theatre techniques, in which the professional actors, the designers or even users themselves may perform the scenario. Sato and Salvador (Sato and Salvador 1999) used theatre techniques in focus group sessions (named as focus troupes) in the context of new product design. Their aim was to include the users in the early stages of the design process. The designers of the product were also present during focus group sessions for responding to the users' questions, which made the session more interactive. The researchers have chosen to use professional actors.

- **Video recordings**

Video recordings might be used to show the realistic usage situations or idealistic ones. The idealistic ones may be used for evaluating the envisaged functionalities of a system/product. For example, new system design hardware may be not available or be difficult and costly to model it as a whole. Thus, the preliminary versions of the system may not work correctly. However, a video of the prototype usage may be prepared for removing these restrictions. Tognazzani (Tognazzini 1994) used video of the prototype usage for a next generation computing-communication interface named Starfire. In the video, in contrast with the reality, the user shows no difficulty to use the interface and everything works as planned. Similarly, Balaguer et al. (Balaguer et al. 2001) used the video recording of the prototype usage of the augmented reality system of an archaeological site. On the other hand, video recording of the realistic usage may be used for the test of prototypes or mock-ups of the product or system. Rasoulifar et al. (Rasoulifar et al. 2007) used this technique in order to evaluate the surgical prototypes and their use. During the project the user was video taped while using a prototype, by respecting to the written scenarios. Moreover, video recording of drama performances to gather insights from elderly people for a home monitoring system is also used (Marquis-Faulkes et al. 2003; Newell et al. 2006). The authors have used professional actors, scriptwriters and directors for the drama performance, so that they preferred drama videos to live performances because of the cost factor. The animated sketches may also be used as a vehicle for communication of the product functionalities to the users that have not so much technological knowledge. They are composed of visual elements (such as photos, sketches, comics, etc.) and sound effects. Lowgren (Lowgren 2004) used in his movies the pictures generally taken from the old books (as background elements) and hand drawn sketches (as foreground elements), and combined them with sound effects.

- **Discussion on the different media used for scenario representation**

In unstructured textual format, because the concept of the product or system looks like incomplete and informal, the designers and users are not attached to the concept. Thus, they feel freer to offer suggestions and changes on the scenario context. Making changes on them is easy and cheap. Rolland and Proix (Rolland and Proix 1992) support the idea that the conceptual specification can be generated from a description of the problem space provided through natural language statements. However, Ryan (Ryan 1993) highlights some risks of using natural language in requirement analysis. One of the listed obstacles is the difficulty of using natural language in complex systems. He argues that *“neither informal speech nor natural language text is capable of expressing unambiguously the myriad facts and behaviours that are included in large-scale systems and this would be true even if we had solved the problem of natural language understanding, which we have not ”*. Formal textual representation differentiates from non-formal textual representation by the clear separation between user actions and system responses. For example, Potts et al. (Potts et al. 1994) mention that: *“tables, unlike natural language, encode temporal sequences unambiguously”*. Nevertheless, the knowledge to create formal texts in the early stages of the product or system design might be difficult to gather, because the interaction of the actors and product/system are not clearly defined yet. Measures and suitable processes are also needed to determine how much formality is needed to achieve consistency and reduce ambiguity in textual format (Glinz 2000). Ben Achour (Ben Achour 1998) proposes a process of quality scenario authoring for system design that consists of two main steps: scenario writing and scenario correcting (which involves the clarification, completion and conceptualization of scenarios).

On the other hand, storyboards are judged to be more engaging to discuss with stakeholders rather than narratives, because they are more realistic with real pictures, real people and their real experiences (McQuaid et al. 2003). They are also discussed as an effective way to empathize with users. The visual nature of storyboards also makes them more powerful communication tool compared to the narratives. Colin (Colin 2008) explains this situation by the fact that *“the activation of meaning from an image generally occurs in a small fraction of a second, much less time than it takes to read a paragraph of text. This activation through a single glance makes images far more efficient than words at conveying certain kinds of information”*. The storyboards, e.g. picture scenarios, are not much time consuming and do not need special sketching or programming skills (Pedell and Vetere 2005a). Because they represent the use as well as its environment, the design actors then focus on changing not only use habits but also the environment they are used in. Parallel actions can also be represented easily through picture scenarios. The storyboards like as caricatures also help designers to discuss issues more freely, which are otherwise, might be seen as sensitive or embarrassing (Erickson 1995).

One another discussed media theatrical performance, is claimed to be different from written descriptions because of the emotional dimension (Newell et al. 2006). The users are expressed through their characteristics but also through mimics and gestures. Nevell et al. argue that *“the emotional attitudes of the users can be as important as their physical and sensory abilities, and we need to explore ways in which this aspect of the users’ characteristics can be highlighted”* (Newell et al. 2006). Theatre techniques also provide active participation of the audience to the scenario construction process. For example, the forum-theatre technique, which is developed by Augusto Boal (Boal 1995), gives spectators opportunity to react on the scenarios and propose changes simultaneously. The personage described by the actor can also be changed easily according the audience reactions. That means the audience has an active participation into the dramatic action that they are watching. Mehto et al. (Mehto et al. 2006) applied this method to gather interactive input from the users. The authors claim that the drama techniques encouraged users to interact with each other as well as the design actors. They also indicate that: *“this interaction creates situations, where the participants will be carried away thus conveying feelings and perceptions that they cannot and dare not to explain by words”*. They produce emotionally more intense information, because the stories are told in much more personal level (Mehto et al. 2006). Similarly, the real actors are argued to hold the attention of the audience during the discussions and promoted engaging and interactive experiences (Sato and Salvador 1999).

The advantage of the video recordings is that they are reclaimable. The same video can be shown many times without additional cost. It is also easier to show the usage of something than explaining it. Moreover, video provides the opportunity to explore social issues together with technical ones. For example, the video of the prototype usage allows design actors *“to stimulate some of the characteristics that they do not know yet”* (Balaguer et al. 2001). On the other hand, by analysing the video recordings of the real prototype usage, the designers can detect the limitations of the prototype and define new functionalities (Rasoulifar et al. 2007). Moreover, the animated sketches, which look less definitive than video recordings of usage activities, encourage constructive communication. Lowgren (Lowgren 2004) states that it takes some time and effort to create animated sketches, which makes them, less than ideal for rapid thinking-by-sketching. Nevertheless, they were effective in conveying to the clients a clear understanding of the design concept and its use qualities, that is why they are qualified as worth to spend time.

However, Marquis-Faules, et al. (Marquis-Faulkes et al. 2003) argue that *“...video is more restricted then using live performances, and may not have the same impact”*. In

contradiction with the denoted cost drawback, Sato and Salvador (Sato and Salvador 1999) argue that the video is neither quick nor less expensive compared to the live performance. Even though scheduling the participants and having actors available might also be suspected to be troublesome, Sato and Salvador, indicated that they had not any difficulty. They enforce their assumption with the argument that the possible changes on scenario may cause reproduction of the video. They also claim that using professional actors is not an obligation. Kantalo et al. (Kantola et al. 2007) also support that idea with the assumption that every human has a capability to act and improvise. They argue that using trained actors may even be harmful. Based on their experiences they explain that: *“the use of traditionally trained actors, who may have great and sometimes even egocentric artistic ambitions, may even be harmful to the interaction with the users. This can happen if the audience’s or participants’ attention is focused on the actor’s skills or elaborate aesthetic forms”*.

To conclude, the discussions above show that each medium has its strengths and shortcomings. As mentioned before, we are focused on the preliminary stages of the design process. Because in this stage the ideas are yet fuzzy, it is better to use easy to create, expand and reject media. Thus, representing scenarios with unstructured textual or storyboard format in this stage seems to be more relevant. Similarly, due to the fact that these medias are cheaper and less time consuming compared to the other ones, they are more convenient for the early stages.

2.2.2. The Content of Scenarios

Scenarios are generally created based on the initial studies realized to get information about users and their work situations. To name a few, studies of different documents, records, etc., interview with end users, observation, analysing the videotaped end user activities and participant observation are commonly used to build scenarios (Carroll 1998).

Different levels of description and many grains of detail might be considered in scenarios. Bodker (Bodker 2000) defines two kind of scenarios: *open ended scenarios* give broad and conceptual answers and *closed scenarios* tend to give more detailed and specific answers. Scenario building is described as an iterative process moving from wrong, sketchy, implausible scenarios to robust and believable ones (Suri and Marsh 2000). So, open-ended scenarios serve well in the early phases of design; where as closed scenarios may serve particular purposes, such as testing of a particular solution, later in the process. In literature the ambiguity is generally matched with the creativity. Goel (Goel 1995) mentions that informal sketches that are ambiguous symbols support creative design thinking. Similarly, open-endedness, incompleteness or roughness of scenarios is supposed to encourage creative thinking

by leaving some details out (Erickson 1995). Carroll (Carroll 1995) also argues that open ended and fragmentary scenarios help developers and users pose new questions, question new answers and open up possibilities. On the other hand, closed scenarios can be used to test the usability of the prototypes of the products. The users can be confronted with the prototypes/mock-up and asked to test them by respecting the written scenarios. Then, the breakdowns of the prototypes/mock-ups can be detected before going further in the process. Briefly, it is commonly agreed in the literature that, in the early stages scenarios are described as open-ended and fragmentary.

2.3. Scenario Usage

In this section, we focus on how scenarios are used in design process.

2.3.1. Scenario usage in design

In this section based, we listed the reasons for what the scenarios used in design process. Campbell (1992) lists four main purposes of scenario use in HCI: illustrate the system, evaluation, system design or re-design and test the theory. Carroll (Carroll 1999) also listed the challenges and approaches in scenario-based design (see Figure 5).

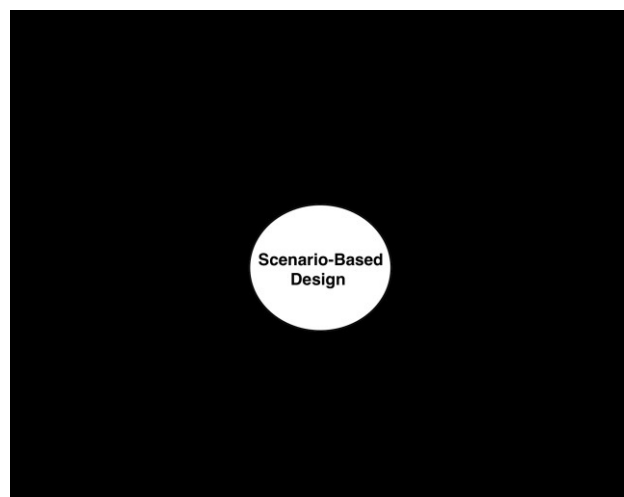


Figure 5 Challenges and approaches in scenario-based design (Carroll 1999)

Based on this categorization and by considering also the new usages adapted afterwards, we listed the main roles of scenarios in design as below:

a. Requirement elicitation

Scenarios are used to describe the actual use situation, before the design of new product/system. Kyng's (Kyng 1995) defines them as "work situation description" and Rosson

and Carroll (Rosson and Carroll 2002) call them as “problem scenarios”. The purpose of the scenario usage is to discuss around actual situation and identify the futures that might have positive or negative consequences on end users (in Rosson and Carroll’s term the “claims analysis”). This process helps designers to analyse requirements, elaborate them and identify new ones. These scenarios facilitate the decision making, because they point out the issues in the current way of working that need to be considered (Bardram 2000).

b. Envisioning

Scenarios are used to represent the future usage of the system or product, called in the literature as “use scenarios (Kyng, 1995)” or “activity scenarios (Carroll and Rosson, 2002). The aim is to find solutions to the present limitations defined in the actual situations. These scenarios are used to show how new system/product might enhance, change or erase actual situation.

c. Evaluating

Scenarios are used to evaluate the envisioned situation with the end users for analysing whether the requirements are fulfilled. The users might be asked to test the prototype/mock up by respecting step-by step scenarios to carry out a task or reaching the goal. In this way the potential problems and opportunities of the further design are detected (Nielsen 1993), pp. 197-225. The scenarios are changed and enriched throughout the testing process.

d. Creating a shared language

Lloyd carried out a study that focuses on verbal communication of engineering design groups in a small design and manufacturing organization (Lloyd 2000). He observed that during the design process, complex social and technical scenarios are deconstructed, understood socially, and then reconstructed into a word a phase. These words had a commonly agreed meaning, which was negotiated through a particular discourse that the story no longer needs to be re-told. Hence, a new language is created and shared, which has to be learned. On the one hand, this language ensured the effective communication within the group. On the other hand, it caused “narrative gaps” for the people who were not present during the story telling phase. In other words, understanding what is being talked about was difficult for them without further information.

Scenarios also make the communication between designers and users more effective, that the users are easily involved in the design process (Erickson 1995). Due to the fact that the users can speak the language, they can work together with design actors. Newell et al. (Newell

et al. 2006) used scenarios to gather insights from elderly people for a home monitoring system is used. The authors demonstrate that despite the complexity of the concept of the product discussed, the user, who has no technical background, understood its functionality in an enjoyable manner and reacted to it. The authors also indicate that they obtained useful inputs that directed their preliminary decisions, which means that the users were actively involved to the decision making process. They conclude that the videos were effective for integrating the elderly people to the design process.

e. Capturing design rationale

Logically structured output of the design process could make the reasoning behind the design process more clear and visible for people who are willing to build on or reuse certain parts of an existing design. Even the members of a design team can better understand the decisions they were not personally involved in. The design document has to not only explain how the product works and show what it looks like, but also “why?” behind the design decisions. For example, why a particular function was (or was not) included, or why the product looks or behaves the way it does. Kyng (Kyng 1995) mentions that one of the reasons that they use scenarios is to “*keep trace of design rationale, a pointer to the situations that inspired the requirements, and in this way constitute some of the reasons for the requirement*”. Scenarios can be abstracted and categorized to help designers capture the knowledge they get from their experience and reuse design insights and solutions for further projects. Lee (Lee 1997) lists the advantages of such tools could offer, which includes providing better support for redesign; reuse; maintenance; learning; structured documentation; collaboration; and management of projects and dependencies.

2.3.2. Scenario-Based Design Framework

In scenario-based design a clear guidance is needed to understand how to create and apply scenarios effectively in each step of the design process. Note that all scenario-based design approaches are not discussed here. In order to get more information check (Anton and Potts 1998; Rolland et al. 1998), which run comparative studies on different approaches.

We adopted in the study the Rosson and Carroll (Rosson and Carroll 2002)’ scenario-based design framework for employing scenarios of use (see figure 9). The framework starts with understanding the real situations, which provides data about the needs and opportunities. The authors point out the necessity of realising the field studies or analysis of stakeholders for understanding the current activities and work practices. They use the term stakeholder, in the

same way with us (see Chapter 2 section 4.1), for the “*person or organization, who will be affected (positively or negatively) by the system*”.

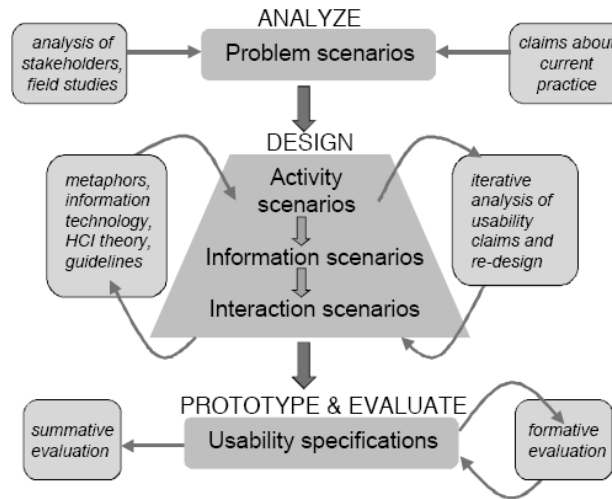


Figure 6: An overview of the scenario based design framework (Rosson and Carroll 2002)

The *problem scenarios* describe the current activities of the hypothetical stakeholders. They are the starting point for acting in design. Claims about the current practice list the positive and the negative consequences of the key features of the current situation for the stakeholders. The scenarios used in the design stage tell the stories about possible future systems. The focus of *activity scenarios* is to respond to the users’ need with the support of a new system. Claims analysis of the current situation help to keep positive features and to find alternative solutions for eliminating the negative ones. The authors talk about two techniques that inspire the exploration of solution ideas: metaphors and available information technologies. They also see the designers’ knowledge of human-computer interaction and of interactive system design is a basis for finding design alternatives. *Information scenarios* elaborate activities by including perceptual and presentation details. They represent how actors perceive, interpret and make sense of information. *Interaction scenarios* include the details of the interaction of actors and system while the actor is realising task activities. The framework is an iterative process where each set of scenario is fed by claims analysis. Finally, in last step scenarios and their associated claims are combined to create usability specifications. A usability specification refers to “*the representative task context that has been analysed into critical subtasks, with each subtask assigned target usability outcomes*”. The prototype then can be tested with representative users, and results can be compared to the target outcomes. The proposed framework is highly iterative. In this study, because we are concerned with the early stages, we are limited with problem scenarios and activity scenarios.

3. Persona Approach

The use of personas in product design is officially introduced by Cooper (Cooper 1999). The approach is to gather information about the users' goals, behaviours and preferences, afterwards use this data to create vivid fictional individuals. Personas are then fictional characters, which have names, details, and goals. Cooper et al. argue that by focussing on the behaviours and the goals of specific personas, the designers can satisfy the needs of a group of users with similar goals (see Figure 7)(Cooper et al. 2007).

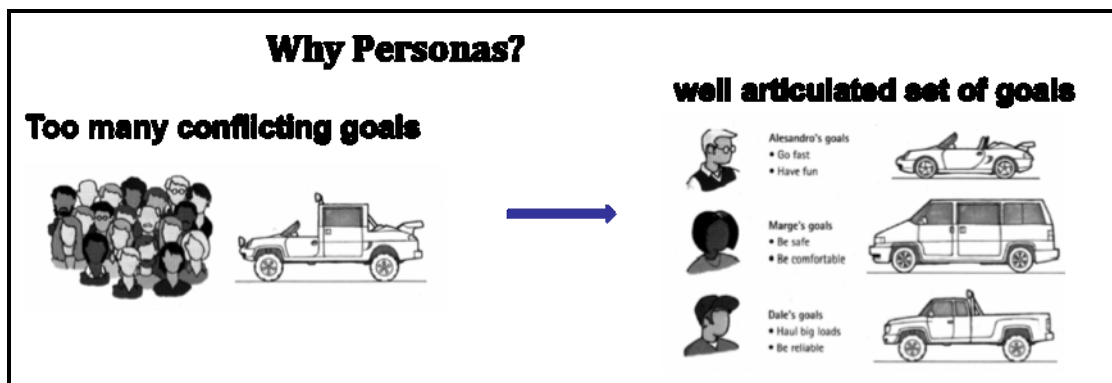


Figure 7 An example of how personas are useful ((Cooper et al. 2007), pp.78)

Previously in marketing, Moore (Moore 1991) also introduced the concept of focusing on one group of customers at a time, which seems like persona approach in some extent. They provide a unified user picture of the product to be designed. Persona use does not require eliminating the other user-centred design methods. On the contrary it is a technique that supports user testing and other evaluation methods, field research, scenario generation, design exploration, and solution brainstorming.

Pruitt and Adlin (Pruitt and Adlin 2006) divide persona process into five phases: family planning, conception and gestation, birth and maturation, adulthood, and lifetime achievement and retirement. These phases should be summarized as: 1) *Family planning*: The user research phase for personas creation; 2) *Birth*: The phase that personas are created based on the research data; 3) *Maturation*: Personas are started to be accepted in the organization and continue to be developed and expanded; 4) *Adulthood*: Personas have taken their place in the design work and started to be used continuously; and 5) *Lifetime achievement/Retirement*: There is no more need to personas in the process, but they are used for the evaluation and the future concerns.

In the following, the persona process discussed under two main phases. The first phase is the persona-building phase during which the personas are created, which seems to cover the first three phases of the framework proposed by Pruitt and Adlin. The second phase is the usage

phase that the scenarios are employed in different ways for different purposes in the design process. This phase covers the last two phases of the framework.

3.1. Persona Building

3.1.1. Personas are created based on user research methods

Cooper et al. (Cooper et al. 2007, pp.49-72) emphasizes the importance of creating believable personas. They mention that like any models, personas must be based on real-world observations. They argue that in order to gather clear and detailed knowledge of the users, qualitative research techniques rather than quantitative methods have to be used. They list the qualitative methods that can support and supplement the creation of personas, like as stakeholder interviews, user observation/ethnographic, etc. The other types of research, such as focus group, market demographics, etc. can also be used. Because different data sources contain different types of information, a combination of these research methods can be addressed, rather than relying on a single method. However, they underline that none of the supplemental data can replace the direct user interviews and observation.

Pruitt and Grudin (Pruitt and Grudin 2002) propose to start with quantitative market segmentation. Afterwards, the highest priority segments are defined through other user centered research methods like as: field studies, focus groups, interviews, etc. Personas are then built a means for communicating data obtained through these user research methods. Likewise, Pruitt and Adlin (Pruitt and Adlin 2006) believe that best personas come from a variety of sources, including both quantitative and qualitative data. However, they also argue that collecting the data, then after analysing and translating it into persona can take so much time and energy. In the case that the team has difficulties to find data, the authors propose to create assumption personas base on the intuition of team members regarding to the target market. They highlight that *“assumptions are really educated guesses often based on real-world experience as well as knowledge of domain and business”*.

However, Sinha (Sinha 2003) criticizes the persona creation strategies based on qualitative methods. He underlines that there is no rigid link between user research and persona building. Thus, the subjective judgement of what user archetypes to focus on might be difficult for inexperienced user. He also extended that even the experienced designers might focus on different personas based on the same user research. The author proposes the usage of Principal Component Analysis (PCA), a quantitative method, which identifies important underlying factors based on large datasets. The personas are then created from the components identified by PCA analysis. On the other hand, Antle (Antle 2006) proposes to integrate the users themselves

to the persona building process. Hence, they might permanently approve personas in order to ensure that they are realistic and explicit enough.

3.1.2. The number and the type of persona

Designers can design for several personas simultaneously, knowing that they represent the needs of many users. They might be used simultaneously during a design process, which enables to focus sequentially on different kinds of users. For example, the design group might discuss one day on the goals of persona Judy, the next day on persona Bob. The number of personas that will be used during a project is discussed in the literature. They commonly agree that because each project, product, and team is different, there is no right number of personas to create (Pruitt and Adlin 2006; Cooper et al. 2007). However, creating large set of personas might be problematic. Because the design team risks of not knowing any persona very well, which will complicate the discussion about their goals and behaviour patterns (Goodwin 2001).

Don and Petrick (Don and Petrick 2003) recommend limiting the number of Personas by using the Market Segment Matrix. They claim that even if there is no certitude of a one-to-one mapping between the prioritization of the market segments and the number of personas to be created, the matrix will help to identify the target users. However, some targeted segments may require multiple personas, while the others none. In the travel company example given by Don and Petrick (see Table 3), each axis in matrix represents the most relevant variables that are gathered from the market research. The “X” represents the segments with behavioural characteristics distinct enough, which justify the creation of the personas. The gray cases represent the segments that are categorized as beside the company’s objectives, after the prioritization based on the market research and core business competencies. For this reason, no personas were needed for these segments.

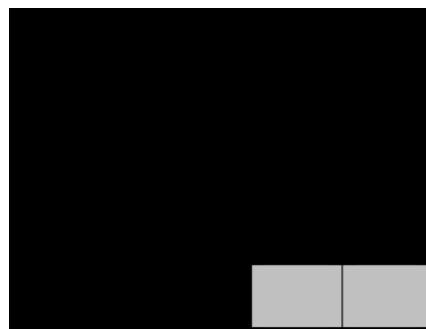


Table 3: Market Segment Matrix for a travel company (Don and Petrick 2003)

Market segmentation supplies quantitative breakdown of the market, which is a great input for persona development. However, it does not provide the required qualitative analysis of

user behaviour, which guides personas writing. On the other hand, Suri and Marsh (Suri and Marsh 2000) highlight that the built personas have to present also the range of extreme characteristics, in addition to average users, e.g. young and elderly, novice and expert, etc., in order to ensure anthropometric fit. Another danger is that the buyers and the users of the product are not necessarily the same people. So, marketing result might be confusing for the design team, which focus on user needs. We can conclude that market segmentation and personas are complementary tools that inform but not replace one another (Brechtin 2002).

Cooper et al. (Cooper et al. 2007) argue that trying to create a design solution that satisfies simultaneously the needs even of three or four personas can be fairly overwhelming. Thus, they propose to prioritize the created personas in order to determine a single persona (named as “primary persona”), which should be the primary design target for a given interface. They clarified that a given product might have multiple distinct interfaces that are going to be addressed by a different persona. They have given the example of a health-care information system that might have clinical and financial interfaces, both are targeted at a different persona. The advantage of limiting the number of personas is that it will force design team to define and clarify the business goals as early in the process as possible. Afterwards building a product that satisfies these goals will be easier. The authors also mention that once the primary persona’s needs are satisfied, then the design group can focus on secondary personas. Secondary personas are happy with the primary persona’s interface with a few specific additional needs, which should be satisfied without upsetting the primary persona.

However, as Pruitt and Adlin (Pruitt and Adlin 2006) express that it is more difficult in practice: *“Even if you do have a go-ahead from the executive team to create one primary persona per product interface, you may not know how many unique interfaces (and therefore how many primary personas) you should create. Many find themselves facing a chicken-and-egg dilemma: should you decide how many unique interfaces your product needs and then create personas or should you create the personas first and then create user interfaces accordingly?”*.

To conclude, in the literature there is no common agreement on the numbers of the personas to be created and if it is necessary to prioritize them or not.

3.2. Persona Usage

In this section, we discuss the way the personas are used in design process.

3.2.1. Personas as a communication tool

Personas are mostly used as a discussion tool that helps designers to communicate in a more informal manner (Gudjonsdottir and Lindquist 2008). They allow designers to deal with a full spectrum of data gathered about the users. By using personas the designers rather than an individual mental model construction of the user, create and use an explicit description of user. They provide a common language between designers, stakeholders, end users and developers to discuss about the design problems and possible solutions.

Personas also provide designers to get a degree of freedom and honesty in the conversation. For example, in the case that the focus is on the characteristics of people that not to be proud of, e.g. drug or alcohol addiction. The designers will scare of damaging their required profile within the group. They will then try to tell anecdotes, which conform “idealised community stories” (Snowden 2000). However, with personas design team moves from an “I” story to “he/she” story. They are not specific to an individual or people known to the group. So, they will feel freer to discuss about, argument or criticize the ideas.

3.2.2. Decision making with personas

The product features can be prioritised based on the persona goals. They guide designers to make decisions about functionality of the product and design. Don and Petrick (Don et Petrick 2003) claim that once the personas created, they might be used to prioritize the needs in relation to product functions. They claim that even if personas have different characteristics, they often share common needs. Creation of the persona need function chart allows design team to define the needs that are not met by a product function/feature, and vice versa. Likewise, Grudin and Pruitt (Pruitt and Grudin 2003) also propose a feature-persona weighted priority matrix that helps designers to prioritize features for a product development cycle. Identifying these themes early in the design process, will help designers to make decisions about features/functions by recognising and communicating their underlying assumptions about who will use the product and in which way. Then the team can decide which features/functions would be eliminated and which ones would be kept.

3.2.3. Keeping users alive

The main role of the personas is to keep the users alive during the process. Thus, it is quite important to assure the sustainability of the personas during the design project. Then, in order to keep the personas alive, different kinds of methods are discussed in the literature.

Pruitt and Grudin (Grudin et Pruitt 2002) propose the creation of a central foundation document for each Persona that contains all information about him/her, such as work activities, computer skills, a day in the life, etc. Then, any new emerged data is mapped back to original data source. The authors also suggest the usage of posters, T-shirts, flyers and other materials, which will remind their existences. A web site might be organized, in which all the materials about the personas should be stored, such as the foundation documents, posters (see Figure 8), supporting tools allowing the usage of scenarios (e.g. spreadsheet tools, comparison charts...), etc. Based on the twelve-week participant observation in an IT-company, which was implementing personas to the design process, Blomquist and Arvola (Blomquist and Arvola 2002) underline the importance of persona communication. They claim that while few people knowing about the created personas, the sketches, screen dumps and photos of the personas hanged on the wall caused many people, who are passing by, to realize spontaneous design meetings, even with the people besides the project.

The wiki is previously used in the literature for the documentation of personas and scenarios, as well as the essential definitions and the description of the method (Gudjonsdottir and Lindquist 2008). In this way, all the team members access to these documents through whole process. Another way is to develop life-size personas that can locate in the project environment in order to bring personas to life (Gudjonsdottir and Lindquist 2008) (see Figure 8). Besides, the e-mails can also be sent out between design actors to share some information about the personas. Pruitt and Grudin inform that they have also created new e-mail addresses for the personas, that the team members were receiving regular e-mails with news of the personas.



Figure 8: Respectively the example of life size personas (Gudjonsdottir and Lindquist 2008) and the persona poster (Pruitt and Grudin 2003)

Additionally, Pruitt and Adlin (Pruitt and Adlin 2006) suggest the usage of little reference booklets which are inexpensive to create and also easy to carry and share (see Figure 9). They are the flip cards; on front page the persona's photo is printed and on the back page his/her personal information. These cards might be used in meetings and out of the meetings. It is an easy and fun way to share information through team members.



Figure 9 Persona flip cards (Pruitt and Adlin 2006)

3.2.4. Personas reinforce empathy

As discussed in previous chapter, the involvement of users in design process is crucial in order to elicit their real needs. However, the choice and availability of the suitable users, cost and scheduling might be problematic for their involvement. Although the personas cannot replace the users in every respect (such as usability testing, etc.), it gives a clear view of for whom they are designing the product.

On the other hand, as mentioned before, in the absence of user information the designers have tendency to focus on their own beliefs and needs for the product design. Thus often cause to self-referential user definitions. However, personas move them away from the view of themselves as users. Personas help the designers to use empathy, stepping on users' toes, in order to understand their real needs. For example when the designers discuss about product features they don't ask if they are interested in this feature. But they will try to answer if the Persona will be interested with it. Personas allow them to explicitly define the user, instead of internal and largely unconscious conception of the users.

Especially, for the design projects that the real users' characteristics are far from the designers' ones, it is more difficult to be involved with the user. For example, a right-handed female designer with computer training may have a hard time developing a successful workstation for left-handed male artists with a more relaxed and freeform work style. Thus,

understanding the physical, intellectual, and personality differences among users is vital for the designers. For example, Antle (Antle 2006) used child-personas for an experimental web development project for the 8 to 10 year old audience. She mentions that creation of the child-personas helped design team, which was not in daily interaction with children and not trained in designing for children, to have empathy for and a deep understanding of the target audience. The team members found that the child-personas were more real than the real children that they were interacting with. Similarly, Astbrink and Kadous claim that the creation of a disability persona and scenarios helped them to define the functional requirements of a wireless communication and information device for blind and physically disabled people (Astbrink and Kadous 2003).

3.2.5. Design Rationale

As discussed in section 2.3.1.e, design rationale offers not only decisions but also the reasons behind them, including justifications, other considered alternatives and the arguments leading to the decisions. Capturing the created personas can guide the team to understand the reasons of the taken decisions. However, Goodwin (Goodwin 2001) argue that the design team might want to reuse a persona for future projects. However, the author argues that this does not work because the effective personas are focused on the behaviours and goals related to the specific domain of the product. He express that although the same name and personal details might be kept, the rest have to be reformed for each product.

4. Limits of scenarios and personas

Even if the usage of personas in design process might have many advantages as listed above, some limitations are also discussed in the literature.

- Choosing the right persona as representative of the target market is a real challenge, especially in the case of developing an entirely new product. There is no guide or test to validate whether the set of personas are accurate and appropriately represent the population of interests (Chapman and Milham 2006). Likewise, there is no a good way to ensure that personas and personas are built and used properly. Unrealistic personas and scenarios with non-persuasive names, shoddy photos, and etc. might also distance the development team from real concerns of the real users.

- The personas and scenarios might be found non scientific and design actors might refuse to be integrated in the process. Gudjonsdottir and Lindquist used personas during

an European project called NEPOMUK (Gudjonsdottir and Lindquist 2008). The authors claimed that the project members did not use personas for making design and the development decisions because they found the personas not relevant for technical problems: *“the personas were not relevant for these discussions because they are about fundamental technical solutions and not about interface”*.

- Design team might focus more on persona’s bibliography and forget the essential. Gudjonsdottir and Lindquist indicate that team members complained about the details in the persona descriptions. Below one of the participant’s criticism about the details of the persona Claudia is given: *“Now you have to bear in mind; all participants of the project are computer scientists, which means we don’t give rat’s ass whether Claudia got a cat or not!”* (Gudjonsdottir and Lindquist 2008).

- Another risk arises from the dimensionality mentioned by Chapman and Milham (Chapman and Milham 2006) is that as the specificity of a persona increases (i.e. its number of features), the proportion of the population represented by the persona decreases. In order to prevent this the design team needs to focus on information essential to design: workflow and behaviour patterns, goals, environment, and attitudes of the persona, not personal details (Goodwin 2001).

- The number of scenarios and personas that would be created for a project is also problematic. Creating non-manageable set of Personas might cause difficulties during a design project. The team members can have difficulties to remember them all. Similarly, Nielsen(Nielsen 1993, pp.357) mention that the number of scenarios that might be further detailed and qualified, are limited depending on the time and material required.

- Blomquist and Arvola (Blomquist and Arvola 2002) claim that separating the personas creation from the rest of the design process made design team to loose their trust on the personas. Because, the team members, who are not participated to the persona creation, were unconscious about which part of the personas were based on assumptions and which parts on empirical material, they felt uncomfortable about persona usage. Carroll (Carroll 1998) also highlights the importance of creating believable scenarios based on research. Otherwise they risk directing the designers to wrong objectives.

5. Concluding remarks

In the following, we summarized our deductions on the literature review on these methods:

Scenario Building: Literature review on the scenario building shows that scenarios can contain five main elements: actors (Who?), their activities/tasks (What?), the environment (Where?), the goal of their activities/tasks (Why?) and the time (When?). The last three elements can also be categorized under the element “setting” by following Carroll (Carroll 2000)). The way that users are represented in scenarios constructs a subject of discussion between researchers. While some researchers prefer to represent actors vaguely in their scenarios, some others prefer to use more precise representation. In this research study, we support the idea that scenarios are created around personas. On the other hand, the media that are used to represent scenarios are also various. Literature review showed that the unstructured textual and storyboard format are more adapted for the preliminary stages of the design process. It also commonly accepted in the literature that in these stages, the scenarios are open-ended and fragmentary.

Scenario Usage: In the early stages of the design process, scenarios describing actual situation can be analysed to determine missing or unsuitable situations that can be changed by a new design. Hence, they are used to list the user needs to be satisfied. They guide also the creation of the future scenarios that describe desired work context. For further stages, scenarios can be used to evaluate the prototype/mock up of a product/system. Hence, the prototype/mock up can be ameliorated iteratively with user feedback. Another usefulness of their usage is that they create a common language that can facilitate the effective communication. Finally, their capture helps to keep the trace of the design rationale, because they contain information about the rationale behind the decisions. The captured scenarios can also be used as a guide for further projects.

Persona Creation: There is no agreement in the literature on the methods to be based for persona creation, and the ideal number of personas to be used for each project. They depend on the motivation and the attending of the design group. However, the researchers are commonly agreed that their communication in the group is a critical issue. The mentioned techniques should be used to keep them alive during the process. The management also needs to support the design group in order to be sure that the method is accepted as a legitimate method.

Persona Usage: Personas discussed in the literature as communication tool that can keep the users alive and focus the design actors' attention on them. They help to create empathy

with the users, even if in some cases their characteristics might be so far from the design actors' ones. They also facilitate the decision making process, because the design actors consider the same common reference for their argumentation.

However, the success of these methods is related to the way they are created and used in the design group. Training the design team about the approach before integrating it to the process is also crucial. The lack of know-how and feeling unfamiliar with the methodology should prevent the acceptance of the approach as a part of the process. On the other hand, the created scenarios and personas have to be credible in order to be accepted as a scientific method.

To conclude, persona and scenario usage provides a deeper focus on users and work contexts among the design actors. Literature review reinforces our assumption that scenarios and personas have an impact to elicit intended users' needs and having a shared understanding of them between design actors. However, no formal comparative study seems to have been carried out on this matter. In order to test our assumption, a comparative study is designed and conducted. In the next chapter, we will discuss the research methodology adapted for this research project.

Part 2- Research and Experiment Design

The empirical studies are considered to be more related research methodologies that can be adopted to test our assumption. After a comparison of different methodologies, the experimental study is judged to be more adapted to address our research objectives. A reviewing of different available literature is performed to determine how an experiment can be designed, carried out, evaluated, and the outcomes can be analysed. Hence, a structured research methodology is deduced and adopted (Chapter 4). By taking this research methodology as a reference, a laboratory experiment is designed and the protocol of the experiment is evaluated. The experiment design process is described and expanded (Chapter 5). So, the Part-2 is dedicated to the description of research methodology and experiment design process.

Chapter 4 The Research Approach

This chapter describes the research approach adopted. We discuss firstly the logic behind our research method choice. Thereafter, how to design and analyse an experiment is expanded. Finally, in last section, the adopted research approach is discussed.

1. Introduction

As discussed before, design has started to be seen more and more as a social as well as a technical activity. Hence, social research methods have been applied to study this activity. To name a few methods: Bucciarelli (Bucciarelli 1988) applied participant/observation in order to study two different engineering design firms, Tang (Tang 1991) practiced interaction analysis, and Dorst and Cross (Dorst and Cross 1995) used protocol analysis. The researchers focus on observing and understanding the design activity in order to develop effective tools and methods that would support the overall process. Workshops, which are organized to bring researchers around common observation data (e.g. “Delft Protocols Workshop, 94” (Cross et al. 1996) and “DTRS7, 07” (McDonnell and Lloyd 2009)), also show the augmented interest on this area.

The discussions in Chapter 2 and Chapter 3 presented the premise for a hypothesis that scenarios and personas usage can encourage the efficiency of requirements elicitation activity. Then, the question is which kind of research approach can be adopted to study the acceptability of that hypothesis. An ethnographic study might be realized on design groups that use scenarios and personas as a method in a new product design process. However, ethnographic studies are more suited for hypothesis building rather than hypothesis testing. Moreover, scenarios and personas are taking their place in the design of new products quite recently. So, it is not so often that companies use them in their product development process.

On the other hand, personas and scenarios might be introduced to many different groups of design actors, and then valuable information can be obtained from study on the use of the method and the outcomes. However, such studies provide only very limited results, since the rival sources of outcomes, rather than usage of scenarios and personas, might be so numerous. These kinds of research approaches are sometimes pointed out as being “*normally not sufficient for permitting strong tests of causal hypothesis because they fail to rule out a number of plausible alternative interpretations*” (Cook and Campbell 1979). One other shortcoming is

how to be sure that the group would not achieve the same success without using this support. Thus, the findings are usually subjective and unreliable (Campbell and Stanley 1966). That is why a group, which uses these methods, needs to be compared with one, which does not, for the purpose of establishing the real effect. Moreover, nothing can be said about the improvement of the situation unless the outcome is compared to the situation before using the methods. Thus, in this research project the experiments are accepted as more convenient to run a study on the usage of scenarios and personas.

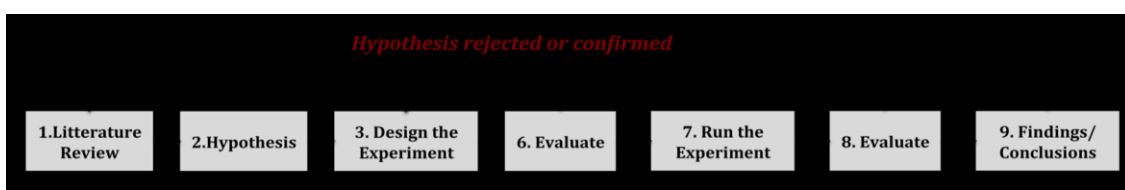


Figure 10: Research Approach

Thus, in this work, we describe a study of engineering design as a social and technical activity, using the scientific method experiment. First of all we detail the reasons for what we adopt an experimental approach rather than an ethnographic study. Thereafter, the experimental approach is expounded in detail (see Figure 10). The method starts with the definition of the hypothesis based on the literature review and continues with the design of the experiment. Then, the experiment protocol is evaluated, whether it is appropriate for the experiment conduction. Once, the experiment is carried out, a new evaluation activity is realized based on the defined criteria. If necessary, the experiment protocol is re-designed and the experiment is re-conducted. Finally, the results of the study are interpreted to check the acceptability of the hypothesis.

2. Ethnography versus Experiment

Both ethnographic and experimental methods have their place in social research. The problem is to select the right method, and then to apply it correctly.

In ethnography, data collection is done by researchers through the observation, which is sometimes combined with the interviews (Fine and Elsbach 2000). While observing, the researcher either behaves like a privileged observer (just observes), or participant observer (acts as a group member). Atkinson and Hammersley ((Atkinson and Hammersley 2007, vol. 3), pp. 3) describe the role of ethnographers in this manner : « *They [Ethnographers] begin with an interest in some particular area of social life. While they will usually have in mind what the anthropologist Malinowski- often regarded as the inventor of modern anthropological fieldwork-called 'foreshadowed problems', their orientation is an exploratory one. The task is*

to investigate some aspect of the lives of the people who are being studied, and this includes finding out how these people view the situations they face, how they regard one another, and also how they see themselves. It is expected that the initial interest and questions that motivated the research will be refined, and perhaps even transformed, over the course of the research: and that this may take a considerable amount of time».

In ethnography, the researchers do not start with any formal theory and hypothesis. Instead they have several theories or hypothesis that are going to become progressively clearer and robust throughout the study. In other words, their role is to incorporate rich contextual data from the real world context (Monk et al. 1993) into theory building (Glaser and Strauss 1967). As Jonsson and Machintosh (Jonsson and Macintosh 1994) claim: *“The researcher’s task, then, is not to seek causal explanations but rather to describe how the actors’ social experience is aligned, organized, perceived and reproduced . . . [Researchers] do not start out with any formal theory and hypothesis, but take the viewpoint of the social actors, and describe the situated character of their interactions over time and the meanings they share”*. In engineering design, several researchers (e.g. Bucciarelli (Bucciarelli 1988) and Lloyd (Lloyd 2000)) adapted ethnography to understand the design activity.

On the other hand, the experiments are run to determine the *cause* and *effect* relationships. In other words, the aim is to test a particular cause, whether has an effect on an outcome, and if so, to what degree. In experimentation, *“the experimenter predicates on the control of situations, comparison of groups that are exposed to different stimuli, and measurement of responses in statistically comparable ways”* (Fine and Elsbach 2000). The experimental approach addresses quantitative data that can be evaluated for their statistical significance, although qualitative data is collected (Monk et al. 1993). Laboratory experiments are used for theory testing (Campbell and Stanley 1966). Besides the fact that conducting a real experiment requires so much effort and is not always possible, they are frequently accepted as a touchstone because they provide significant confidence in the robustness and honesty of causal findings (Bryman 2001). That means that the internal validity of real experiments is so strong. In the context of design, the term experiment is often used incorrectly and there are rare examples of true experiments (Blessing and Chakrabarti 2009).

Moreover, linking ethnographic and experimental approaches, several empirical studies have been carried out in laboratory G-SCOP since 1995 (Blanco 1998, Boujut and Blanco 2003, Chartier et al. 2006, Prudhomme et al. 2007, Ruiz-Dominguez and Boujut 2008, Rasoulifar 2009, Hicks et al. 2009). This constitutes a methodological background for our empirical approach that will be described below.

In this study, we start with a hypothesis and our research aim is to test its validity, that is the reason why we adopted an experimental approach. However, it is important to mention that we agree with Fine and Elsbach (Fine and Elsbach 2000) who argue that laboratory experiments do generate behaviors that can be interpreted qualitatively (not only quantitatively): *“This behavior, like all behavior, results from inferred meanings, expectations, norms, and values. The rules of social interaction, described in detail by sociologists, are not repealed just because a participant enters a ‘laboratory.’ While experimental social psychologists have typically used these descriptions only to add dramatic color to the statistical discussion, such a choice is not inevitable. Descriptions and analyses of social interaction in a laboratory can be effectively merged with numerical dependent variables to understand the situational meanings of participants and can aid in the development of theory. Specifically, social psychologists can use the virtue of the experiment in producing a set of identical situations to treat each instance as an ethnographic opportunity, thus employing the tactic of ‘repeated ethnographies’”*.

In the next section, we focus then on how to design the experiment.

3. Design the Experiment

We divide the design of the experiment under three sub-sections:

- *Experiment Framework*: The experiment framework is the description of the general structure of the experiment to be designed. According to the design question to be answered and to available resources, the researchers need to decide which kind of the experiment (e.g. laboratory or field experiment, experiment or quasi experiment) they are going to conduct.
- *Description of the design situation*: In order to analyse and observe the design situation in an experimental environment, we need a concrete definition of *“what is a design situation?”*. In other words, we need a theory that describes the design situation and its variables, so that while conducting an experiment we can create a situation, which fits on that theory.
- *Experiment process*: is the process respected to conduct an experiment.

3.1. Experiment Framework

In this section, we present a literature review on different kinds of experiments discussed in the literature. In the following, firstly differences between laboratory and field experiments are considered, and then different types of experiments are described.

3.1.1. Laboratory and Field Experiments

Before giving the description of different types of experiments, it is important to highlight the basic differences between laboratory and field experiments. The laboratory experiments are carried out in a laboratory environment or in a conceived setting, where as field experiments are conducted in real-life settings.

There are some limitations of laboratory experiments. One of them is the external validity of the experiment. The experiment set-up is not identical to the real world experiences and contexts. Thus, there is no guarantee that the subjects will exhibit normal behavior under experimental conditions. Secondly, in terms of experience, subjects are mostly students, who are not real representatives of practicing engineers. Thus, their reactions to the experimental treatment might be different from the target population. Additionally, Ahmed et al. (Ahmed et al. 2003) also showed in their study that the novice and experienced designers might differently approach to design tasks. On the other hand, Rosnow and Rosenthal (Rosnow and Rosenthal 1997) mention that being volunteers and non-volunteers also influence the outcomes of the study. Lastly, in terms of the ecological validity, the applicability of the results to the real world and everyday-life may not always be possible.

However, there are also several advantages of laboratory experiments. One of them is that the researcher has a greater control over the experimental arrangements, which consolidate the internal validity of the experiments. In addition, in terms of the replication, laboratory experiments are easier to carry out, because they are less limited with the experiment configuration that is difficult to reproduce.

In some circumstances, it is possible to carry out experiments in field settings, but it is not always possible to have such strict control over variables in the field. In this study, we conduct a laboratory experiment, so that we can have the control over the experiment configuration and we can also reproduce several experiments to ensure validity of the gathered results.

3.1.2. Types of Experiment

The two basic types of experiment, which are currently recommended in the methodological literature, are listed as: experiments and quasi-experiments.

a. Experiments

Experiments consist of two groups: control group and the experiment group. The experiment group is exposed to the experimental treatment (independent variable), while the

control group is not. Blessing and Chakrabarti (Blessing and Chakrabarti 2009) discuss that in design, the treatment could be the training of a design method or the introduction of a new tool. The aim of an experiment is to test, whether a manipulation of the experiment treatment (independent variable) has an effect on the dependent variable. For example, we can analyse through an experiment, whether the new design tool (independent variable) have an effect on the performance of the designers (dependent variable).

The dependent variable has to be measured by the same measurement method(s) before and after the experimental manipulation. The pre-test helps to define differences between groups before the treatment, while as the post-test provides identification of the effects of the independent variable. The subjects are assigned to the groups randomly. The random assignment eliminates the human bias opportunity. For instance, the researcher won't use subjective criteria to choose the subjects, such as if they looked responsible, friendly, etc. Randomization also provides the distribution of non-experimental causes across all groups.

Figure 11 shows the experimental design figuration that "Obs" labels to some process of observation or measurement and "X" refers to the independent variable.

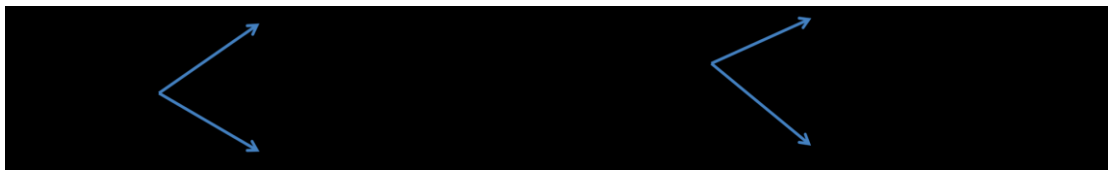


Figure 11 Respectively Experiment and Quasi-Experiment Configuration

To summarize, the essential characteristics of the experiment can be listed as:

- The researcher has the control over the process;
- The random assignments of the subjects to the groups is necessary;
- The subjects and the objects are the representatives of the target population;
- There must be a viable control group;
- Only one variable can be manipulated and tested at once. Even if in some cases more than one variable can be tested, such experiences and their analysis tend to be difficult and unwieldy.

b. Quasi-experiments

Managing the overall requirements of an experimental design is very difficult in many cases. For example, pre-selection and randomization of the groups is often difficult, because of ethical reasons, cost and time constraint, etc. Campbell and Stanley (Campbell and Stanley 1966) mention that an unwanted side effect of the classical experiment is that they create a hopelessness to achieve all of their requirements, and that researchers tend to abandon it for more informal methods and investigations. As an alternative to true experiments, quasi-experiments have certain characteristics of classical experiment, but the researcher has less control over all the experiment arrangements. However, some researchers, argue that researcher has either control over the whole process (experiments) or not (non-experiments), which rejects the idea of quasi-experiments (e.g. (King et al. 1994)).

A large number of different types of quasi-experiments are discussed in literature (Campbell and Stanley 1966). The most commonly used one is the non-equivalent control group design, which has many common points with the experiments. Differently from the classical experiments, in this experiment configuration the subjects are not assigned randomly to the experimental and control groups. Instead of that, the experimenter assigns the subjects to the groups as similar as possible (see Figure 11). The terms “randomly assigned” and “randomly selected” need to be differentiated. As Blessing and Chakrabarti mention that: “Randomly assigned refers to how the participants or the objects in the study are divided into groups to be compared, and thus relates to the setup of the study and the internal validity. However, randomly selected refers to the way in which the participants or objects were chosen to participate in the study, and thus relates to sampling, and external validity”¹⁰.

Although, the similarity of the groups is not certain in the way it would be, if the subjects were assigned randomly, in this experiment configuration the difference between groups can be measured through the pre-tests. Campbell and Stanley mention that: “*the more similar the experimental and the control groups are in their recruitment, and the more this similarity is confirmed by the scores on the pre-test, the more effective this control becomes*”. Furthermore, Patton (Patton 2001, pp. 46) claims that purposeful sampling can be used as an alternative to the random sampling: “*The logic and power of probability sampling derive from its purpose: generalization. The logic and power of purposeful sampling derive from the emphasis on in-depth understanding. This leads to selecting information-rich cases for study in depth. Information rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the research, thus the term purposeful sampling*”.

¹⁰ The definition of the external and internal validity will be discussed in more detail in section 4.1.1

In this research study we choose to conduct an experiment, distinctively instead of random sampling, the subjects are purposefully selected and assigned, which can be categorized as quasi-experiments.

3.2. Design Situation Model

Prudhomme et al. (Prudhomme et al. 2007) propose a collaborative synchronous design situation model, which is adopted for research studies. According to their model, a design situation consists of four main elements: task, object, actor and environment (see Figure 12). A design task expresses a goal and the conditions in which work should be realized, whereas the design object, or the product, is the entity on which the design actors work. The design actors are the people, who are involved into the design process. Finally the environment element is described by the industry, the available technical means and the project organization. This model gives a macroscopic view of a design situation.

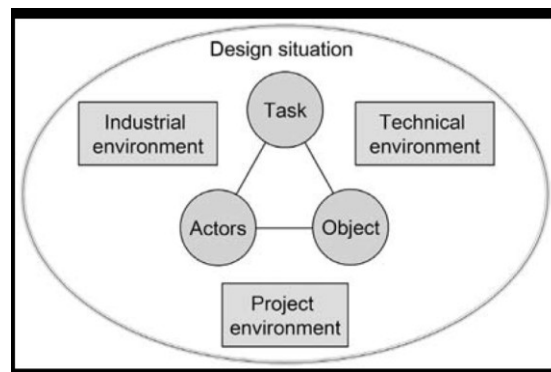


Figure 12: Synchronous collaborative situation model (Prudhomme et al. 2007)

Calsmith et al. (Calsmith et al. 1976) define two kinds of realism to be considered while conducting an experiment: experimental realism and mundane realism. Experimental realism refers to the degree to which the extent setting and procedures are credible, involving and taken seriously. In other words, whether the experimental events are similar to everyday experiences and the subjects are caught-up in them. On the other hand, mundane realism refers to the extent to which the laboratory setting resembles events and variables found in real life. By taking this model as a reference, the relevant considerations that have to be addressed in an experiment to ensure experimental and mundane realism, can be defined. For example, for each element of the design situation model the following contexts can be considered:

- Actors: Number of participants that will take place, composition (e.g. background, age, sex, etc.), role playing (e.g. manager, designer, manufacturer, etc.), formal

authority hierarchy (e.g. patron-worker, student-worker relationship, etc.), sampling type (e.g. random, purposeful (see (Patton 2001) for more detail), etc.

- Tasks: tasks are going to be asked to the participants
- Objects: the design idea that is going to be worked on
- Environment: preparation of experimental environment (e.g. videos, microphones, etc.), facilities to be supplied to the participants (e.g. whiteboard, paper, pen, chair, etc.), sitting plan, participants' location (e.g. distributed or co-located), etc.

3.3. Experiment Process

Tang (Tang 1991) proposes a methodology to study group design activity, which is an iterative approach “observe-analyse-intervene”. The design activity is observed and recorded in the observation phase. Then, this data is analysed and interpreted. In the third phase, new tools and methods are designed that will have an impact on the observed activity. The process is repeated until the researcher is convinced with the findings.

Following Tang, Hicks et al. (Hicks et al. 2009) propose a process model in order to realize a structured observation. This is an iterative approach that involves five main phases: 1) Monitor 2) Capture 3) Analyse 4) Prepare and 5) Intervene (see Figure 13). In the monitoring phase, the researchers define what will be monitored during the design activity: the actors, their interaction, the objects, etc. The technology and the tools that will be used for monitoring are also prepared in this phase. On the other hand, the observers might be present in an experiment in distinct ways (Patton 2001, pp. 265). Their role in the experiment might vary from full participant observation to onlooker observation as an outsider. Similarly, their consciousness about the aim of the study might also be in different levels that they might have full explanation of real purpose or no explanations at all, or even false explanations. If the observers have full explanation about the aim of the study, their active presence on the study might cause the expectancy bias. In some cases even passive presence of the observer in a meeting might affect the behavior of participants. Therefore the observers' role needs to be defined in the monitoring phase. The inputs, outputs, content and relationships between activities and interactions are then captured in the second phase. In the third phase the data is analysed and interpreted. The last two phases are respectively the preparation of new tools or methods that will have an impact on the activity, and ensuring that those interventions are beneficial. Note that, in this study we adopted the Hicks, et al.'s process model.

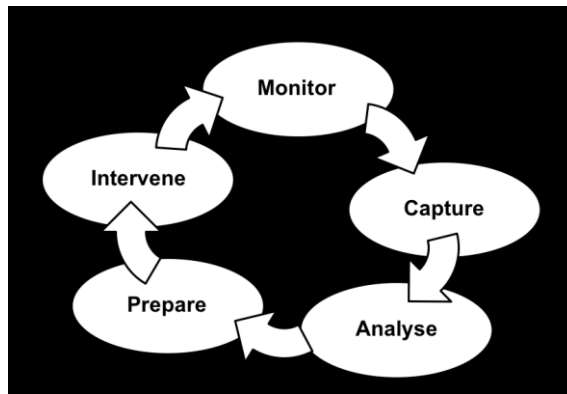


Figure 13 The five phases of process model (Hicks et al. 2009)

With the increasing technological facilities, the way of analysing the design activities takes a new form. Researchers, instead of taking notes, photographs of their observations, use video and audio capture. This immensely rich data captured, with many avenues for analysis, arise the questions of *what to* and *how to* analyse. Visser (Visser 2006) defines the design process as the construction of representations. In this project we focused on the representations of the product by the design actors. Mental representations might be external or internal. The internal representations are mental models that people construct in order to understand the world around (Craik 1943). Since the mental representations are intensely debated within cognitive science, and since they are far from our expertise and background, we focus here on the role of external representations in design. Thus, in the following, a deeper analysis on different external representations and the way they are analysed in the design literature is discussed. Then, three contexts has to be considered to create a coding schema is presented.

3.3.1. Analysis of the External Representations

Individuals differ quite widely in terms of the way that they externalize their reasoning (Cox and Brna 1995). During the construction of an external representation, subjects examine their ideas, re-order them, translate information in one form to another (re-represent), develop them and keep track of their progress (Cox 1996). The term ‘external representation (ER)’ refers to a wide variety of representations in the verbal (discussions), gestural and visual form (e.g. sketching, diagrams, tables, histograms, etc.). Eng et al. (Eng et al. 2008) define the external representations as “*the artefacts (text, diagram, sketch, etc.) that provide an interface to a person’s internal mental models. They are things that have meanings but that exist outside the mind*”.

The ER becomes an important issue when they are shared. They make the ideas sharable and accessible for modification and critique. The learner builds up a personal version

of the represented information. They form the subject to discussion, negotiation, and alteration. It often happens that subjects need to deal with a diversity of knowledge representations and interpretations. Some representations, for example, facilitate the comparison of the values (e.g. histograms), whereas the others facilitate the read of precise values (e.g. tables) (Cox 1996). The strengths and weaknesses of each form of representation affect the efficient communication and capture of the information.

Below, a brief literature review of these different forms of external representations and the way that they are analysed in order to understand the design activity is presented.

a. *Analysis of Design Artefacts*

In the design processes, the design actors use a variety of objects that help them in carrying out their work. They are all sort of physical objects, such as sketches, technical drawings, prototypes, etc., which can be pointed out, talked about or sketched on. These artefacts allow externalization and representation of objectives, constraints, forms, functions, assemblies, and so on (Hutchins 1995).

During a collaborative design process, these artefacts act as a vehicle for communication between diverse groups with different skills and disciplines. Star (Star 1989) entitles them as “boundary objects”, which “like a blackboard sit in the middle of a group of actors with divergent points”, while as Vinck and Jeantet (Vinck and Jeantet 1995) suggest the concept of “intermediary objects”.

Many studies have been conducted to understand the role of artefacts in the design activity. Purcell and Gero (Purcell and Gero 1998) observed sketching activities and they point out that they the sketches are usually unstructured and vague, where as in later stages of the design process they are highly structured and detailed. Goel (Goel 1995) also argued that the unstructured nature of the sketches in the early phases of the design process reinforces the creativity and the innovation. Van der Lugt (van der Lugt 2005) categorized three different roles of sketches: thinking, talking and storing. Storing sketches are useful as memorial aids to record and represent ideas, which are already in the mind, while as the thinking sketches precede generation of new ideas. Finally, the talking sketches are usually used to support group discussions. On the other hand, Blanco (Blanco 2003) drew attention on the significance of sketches in the decision-making process. Furthermore, in concurrent engineering, intermediary objects are accepted as enablers to foster co-operation (Boujut and Blanco 2003). Arikoglu et al. (Arikoglu et al. 2009) also point out that they can enable the design actors to keep trace of the design rationale.

To conclude, the analysis of the design artefacts provides researchers with an understanding of the design activity. By conducting these kinds of studies, the researcher can develop new design tools that will assist designers in their work practice. For example, some new tools might be designed to sustain sketching activity and intelligent capturing process.

b. Conversation analysis

Luck and McDonnell (Luck and McDonnell 2006) list several properties that qualify the study of conversation as a significant source of data to investigate the activity of design:

- *« Design conversations are the medium for the exchange of knowledge and information that will be used in the design process.*
- *Design conversations externalize the creative, designing process that occurs as the conversation takes place.*
- *The social mechanisms of interaction mediate both the creative activity and the exchange of information and these are both displayed during the spoken interaction. »*

Hence, in collaborative design, the conversational data is used as the subject of many studies to interpret the activity of design. Transcriptions of the video/audio recordings generate a base for the studies. Dong (Dong 2005) also realized a study on design team language-based communication to measure the knowledge construction. He makes the hypothesis that *“language (and the meaning of words) is a facilitator to bridge gaps of knowledge between what individual team members know and the larger body of experience held by the team”*. The studies done on conversational data provides insights on design activity and how it can be improved. For example, Lloyd (Lloyd 2000), who analysed the discourses of the design actors in engineering design, points out that *“good design teams do tend to have a well-defined common language to communicate, a language which expresses experience and creates an identity for a particular product »*. For instance, this knowledge can be used to construct and train design teams.

c. Gesture analysis

Compared to design artefacts and verbal interactions, gestures have been least analysed in collaborative design. To name a few, in engineering design Tang and Minneman (Tang and Minneman 1990) and Bekker et al. (Bekker et al. 1995) analysed the gestures of a small design groups, and similarly Gomes and Sagot (Gomes and Sagot 1999) observed the gestures to

envision future activities in new product design. Analysing the gestures can enable designers to design more adapted design tools. For example Tang and Minneman used the gathered results from their observation to design and develop VideoDraw, a shared drawing tool.

However, it is important to note that, because the analysis of gestures is far from our expertise, the gestures won't be in the scope of this study. We will focus on the analysis of artefacts and conversation.

3.3.2. Creation of a Coding Scheme

In order to conduct structured analysis on the external representation presented above, a coding scheme can be created that reflects on the goal of the research. The creation of the coding scheme depends on the three contexts: the objective of the research, the observed situation, the researchers and coders' way of proceeding (see Figure 14). The researchers, according to their research objectives, to the design situation that is going to be observed and to the available technology, construct the coding scheme. For example, if the study is about the interaction form of the designers, the categories might be: management, explanation, proposition, opinion and argumentation (Cassier 2010). In some cases in the research area there might be an available coding scheme (e.g. in engineering design see (Cassier 2010)), which is related to the research approach. In that case the researcher might adapt this scheme to the contexts in which he is working on.

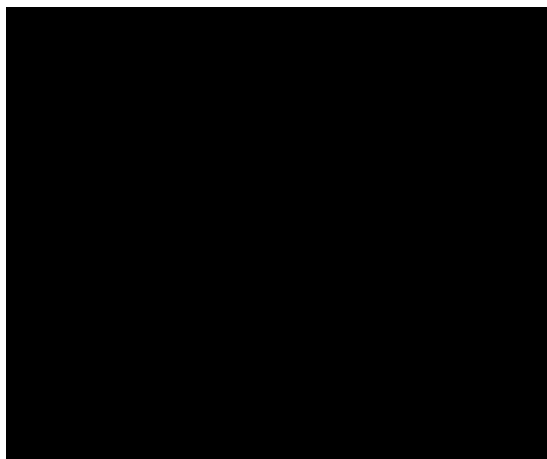


Figure 14: Contexts to be considered for creating the coding scheme

The creation of the coding schema is an iterative process, which means the coding process gives feedback to the coding schema. This process can be seen as a constructivist approach that the coder adapt the grid to his understanding, create a mental model of it and reformulate until it becomes robust enough. Once the grid is completed, the coder has to adapt a

positivist approach to realize coding by accepting the grid as it is. It is important to develop a robust coding schema; hence the analysis process can be automated or simplified, which enables coding by different individuals.

4. Evaluate the experiment

Bryman (Bryman 2001) mentions three main criteria in order to test the validity of social research: validity, replicability and reliability. In this study, while the first criteria will guide the way the experiment is designed, the last two ones will be used for the evaluation of conducted experiments.

4.1.1. Validity

Bryman categorizes four main types of validity:

a. *Measurement validity*

It is related to the question of whether the measures realized do really measure what they are supposed to do in theory. For example, how to be sure that a performance test really measures the performance of the design actors. If they do not, then the outcome of the study is going to come under question. It is to be noticed that, measurement validity presumes that a measure is reliable. It is obvious that an unreliable measure cannot provide a valid measure of the concept in question.

b. *Internal validity*

Internal validity deals with the issue of causality. That means internal validity refers to be sure that if “x” is suggested to produce a variation in “y”, then there is nothing else that has a causal relationship with “x”. Campbell and Stanley (Campbell and Stanley 1966) (based on the previous studies of Campbell (Campbell 1957) listed eight possible threats that have to be considered for the internal validity of the experimental design:

- **History:** occurrence of an event other than the treatment. The longer the study goes for the more likely this is to happen.
- **Testing:** is related to the possibility that the pretest makes the subjects familiar to the measurement or sensitizes them to the aim of the study, which might affect the results of the posttest.

- **Instrumentation:** changes in the way that a measurement is realized or changes in the observers used might affect the outcome. For example, using one observer in one experiment group, but more observers in another one.
- **Mortality:** this threat corresponds to longstanding experiments. In that case some subjects might not continue in the experimental process. For example, some of the subject might walk out on the experiment for special reasons (e.g. sickness)
- **Maturation:** the passage of time might have an effect on the subjects, like as getting older, getting tired or feeling hungry etc. It is valid for longstanding experiments.
- **Selection:** In the groups that are constructed non-randomly, there might be pre-existing differences between comparison groups. In the case that a posttest is not done, this pre-existing difference might be confused with the effect of independent variable.
- **Statistical regression:** operating where groups have been selected on the basis of their extreme scores. That means if the subjects are selected based on extreme scores (high or low), in latter testing they would have regressed to the center.
- **Ambiguity about the direction of causal influence:** an independent variable and the dependent variable presuppose a direction of causality. However, quasi-experiments the differences related to the choice of the subjects might be confused with the effect of the independent variable. For example, suppose that in educational research an experiment is carried out to test the effectiveness of a psychology course for engineering students. The experimental group is chosen from the first year students and the control group from second year students. In that experiment, the selection-maturation effect might then be mistaken for the effect of independent variable.

c. External validity

External validity is related to the generalization of the results. In other words, it refers to whether the conclusions in the study would be valid for other persons in other places and at other times. Internal and external validity are contradictory criteria, because high control and high internal validity mean a reduction of external validity. Campbell and Stanley (based on the previous studies of Campbell (Campbell 1957)) discussed four possible threats that have to be considered for the internal validity of the experimental design:

- **The reactive or interaction effect of testing:** The posttest might change the subjects' sensitivity or responsiveness to the independent variable. In a situation that the posttest is not realized the results obtained might be different.

- **The interaction effects of selection biases and the independent variable:** This is related to the questions of whether the results can be generalized to the wide variety of people with different gender, social class, religion, etc.
- **Reactive effects of experimental arrangements:** the experiments conducted in experimental settings prevent the generalization about the gathered results to the real environment. There is no guarantee that the results can be applied to other settings. For example, because the subjects are aware of the fact that they are participating in an experiment, they may react differently from reality.
- **Multi-treatment inference:** in some experiments multiple treatments might be applied to the subjects. In that case the effects of preliminary tests might affect the further ones' results.

d. Ecological Validity

Although internal validity is acquired, results may not be applicable outside the experimental setting. This criterion is related to the question of whether the findings are applicable to people's everyday natural settings.

The above-mentioned validity categories, on the one hand are considered during the experiment design process. On the other hand, once the experiment is designed they are used to evaluate the validity of the experiment protocol.

4.1.2. Replicability

A study must be capable of replication. That means the protocol of the study must spell out in great detail that the same study can be carried out somewhere else and by someone else. If a study does not enable replication, then the findings gathered by the researcher cannot be reproduced, which will cause a serious problem about the validity.

4.1.3. Reliability

Reliability deals with the question of whether the results of the study are consistent. One of the factors that affect the reliability is the stability of the measure. The measure taken over time has to be stable. For example, if the researcher tests the IQ of a subject in different time samples and obtains the results 87, 95, 103, then the test is not reliable. Similarly, where experiments use human judgment and more than one observer is involved, and there is the possibility that their decisions may vary widely. One other risk, which needs to be considered, is that the internal reliability of the multiple indicator measures. In other words, in the case that multiple-items measure is practiced, the indicators have to relate to the same thing, which

means they have to be consistent. For example, if the researcher conducts an interview and the answers of the subjects are gathered to form an overall score, the researcher has to be sure that the questions are related to each other. In summary, when another researcher carries out exactly the same experiment under the same conditions, if the study is reliable, this should generate the same results.

Blessing and Chakrabarti (Blessing and Chakrabarti 2009), highlights the importance of realization of a double coding to ensure the validity of the gathered results. They claim that: “double coding involves coding of at least a part of the data by two different people or by the same person twice but with a time delay in between”. The presence of a second coder helps to get a more objective look at the coding schema and have a more reliable coding process.

Inter-coder agreement refers to the extent, to which two or more coders agree in their coding. Inter-coder reliability can be calculated between coders by using the percent agreement index. Because it is simple to calculate, it is widely used in literature. However, it is commonly accepted as a misleading measure, because it does not take into account of the fact that some agreements may be taken by chance (Dewey 1983; Grayson and Rust 2001; Ron and Massimo 2008).

$$\text{inter-coder reliability} = \frac{\text{number of agreements}}{\text{number of agreements} + \text{number of disagreements}}$$

Equation 1: Percent agreement index

Scott's pi (π)(Scott 1955), Cohen's kappa (κ)(Cohen 1960) and Krippendorff's alpha (α)(Krippendorff and Bock 2008) are the other most widely used statistical measures. Their advantage compared to percent agreement index is that they take into account the agreement due to chance. Scott's pi and Cohen's kappa correct chance on the basis of the same equation:

$$\kappa, \pi = \frac{\text{Pr}(a) - \text{Pr}(e)}{1 - \text{Pr}(e)} \text{ where } \text{Pr}(a) = \text{relative observed agreement between coders}$$

and $\text{Pr}(e)$ = the probability of random agreement.

The difference is due to the assumptions leading to the calculation of $\text{Pr}(e)$. In the case that coders are operating by chance alone, Scott makes the assumption that coders get the same distribution, while Cohen makes the assumption that coders get separate distribution. On the other hand, Krippendorff's alpha bases on a formula expressed in terms of disagreement. Ron and Massimo (Ron and Massimo 2008) discuss the characteristics of different inter-coder agreement coefficients in more detail. They conclude that in computer linguistic “ K and α are

more appropriate, as they abstract away from the bias of specific coders”, where K labels the Fleiss’s generalization to more than two coders of Scott’s π (see Fleiss 1971). They also add “ultimately this issue of annotator bias is of little consequence because the differences get smaller and smaller as the number of annotators grows”. However, there is no common agreement in literature on which inter-coder reliability is more reliable. While Krippendorff (Krippendorff and Bock 2008) claims that “Cohen’s kappa is simply unsuitable as a measure of the reliability of data”, Dewey qualifies it as a “measure of choice” and it is also commonly used in research and recommended in social research books (Bryman 2001; Coolican 1999). In the following the calculation of the Kappa Index is presented.

Cohen’s Kappa calculation can be explained through an example. Suppose that there are two coders, who are asked to classify the objects into two categories 1 and 2. The table below contains cell properties for a 2 by 2 matrix. The data is as follows, where rows are for coder 1 and columns are for coder 2:

Matrix 1: Cohen’s Kappa: Double coders’ coding matrix

The equation for the calculation for Cohen’s Kappa is:

$$\kappa = \frac{\text{Pr}(a) - \text{Pr}(e)}{1 - \text{Pr}(e)} \text{ where } \text{Pr}(a) = \text{relative observed agreement between coders}$$

and $\text{Pr}(e)$ = the probability of random agreement.

$$\text{Note that } p_{1(R1)} + p_{2(R1)} = p_{1(R2)} + p_{2(R2)} = n$$

$$\text{Thus, the observed percentage of agreement is } \text{Pr}(a) = \frac{(p_{11} + p_{22})}{n}$$

To calculate the probability of the random agreement:

Coder 1 categorizes in the category 1 with the probability: $\frac{(p_{11} + p_{12})}{n}$ and in the category 2 with the probability $\frac{(p_{21} + p_{22})}{n}$

Coder 2 categorizes in the category 1 with the probability: $\frac{(p_{11} + p_{21})}{n}$ and in the category 2 with the probability $\frac{(p_{12} + p_{22})}{n}$

Thus, the probability of random agreement is:

$$\Pr(e) = \left(\frac{(p_{11} + p_{12})}{n} \times \frac{(p_{11} + p_{21})}{n} \right) + \left(\frac{(p_{21} + p_{22})}{n} \times \frac{(p_{12} + p_{22})}{n} \right)$$

Landis and Koch (Landis and Koch 1977) proposed standards for interpreting κ values (see Table 4). If there is substantial or almost perfect agreement between coders, we do not know whether they categorized correctly but we at least know that they are consistent. According to the results gathered if necessary the coders have to get together and clarify the reasons of the differences in their coding. A more robust coding schema might be then created, which will be tested by new coders. If good levels of agreement are found between the coders, then the results of the analysis can be interpreted. In the given example, $\kappa=0,44$ fits into category moderate agreement, which needs to be improved.

Table 4: Standards for interpreting κ (Landis and Koch 1977)

a. Possible biases in experiments

In addition to these criteria, some possible biases that might affect the validity of the experiments are discussed by Coolican (Coolican 1999; Coolican 2006). Below, the important biases concerning the study are discussed.

One of the possible biases is the effect of the being observed on the subjects. It is also called “Hawthorne effect”, which takes its name from a study conducted in the company Hawthorne Works (a Western electric factory) (Roethlisberger and Dickson 1939). The researchers from Harvard University conducted a study in this company to see if its workers would become more productive in higher or lower levels of light. The workers' productivity

seemed to improve when changes were made. However, the researchers realized that productivity increased due to attention from the research team and not to changes in experimental variable. If the subjects are aware of being observed, they might want to please the experimenter and produce the results they think are expected. On the other hand, they might get stressed and afraid of not succeeding, which might impact their performance.

On the other hand, when subjects are informed about the aim of the study, they might react differently. In medicine this effect is called a “placebo effect”, to refer the improvement on the subjects through a medication/treatment, even it is a fake treatment/medication, most likely because the subject believe that it will work.

Lastly, the researchers who are conscious about the desirable outcome of the study may alter the subjects’ behavior in their favor. Coolican gives the example of a study conducted by Rosenthal and Lawson (Rosenthal and Lawson 1964), who asked their students for comparing the learning performance of two groups of rats “dull” and “bright”. The students claimed that the rats group labeled as “bright” learned quicker. However, the rats groups were created randomly, which means that the group labeled as “bright” was not particularly bright at all. The experimenter expectancy may cause different impacts that he/she might unconsciously orient the data gathering and analysing process in favor of the expectations of the study, give some cues to the subjects, etc.

5. Concluding Remarks

In this chapter, we discussed the research approach adopted for this project (see Figure 15), which starts with a hypothesis. An experiment is designed to study this hypothesis. Experiment design activity is discussed under three sub-categories: experiment framework, design situation and process model. Each sub-category is detailed and expanded based on the literature review. The discussed validity criteria are considered for the experiment design, and they are also used to ensure the validity of the experiment protocol. The reliability and replicability of the experiment are evaluated, after carrying out the experiment. After each evaluation activity, if necessary the experiment is re-designed. Thereafter, the outcomes of the study are analysed and interpreted. As mentioned above, we focus on the external representations of the design actors, which means the design artefacts and the conversation. The gestures of the design actors are not covered in this research study. Creation of coding scheme is served as a technique for the analysis of the external representations. Finally, the hypothesis can be rejected or accepted, based on the gathered results.

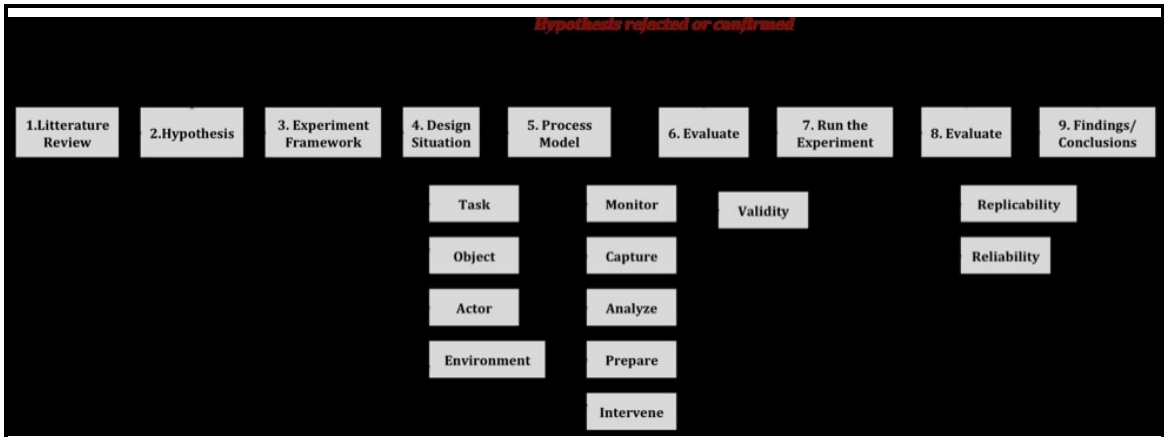


Figure 15: Detailed View of Research Approach

In the next chapter, the experiment design process and the rationale behind it will be discussed in detail.

Chapter 5 Design of the Experiment

This chapter describes the design process of the experiment. First of all the experiment framework is discussed. Secondly, the design situation that is going to be focused on is presented. Finally, the last section discusses about the adopted process model.

1. Introduction

The discussions in Chapter 2 and Chapter 3 presented the premise for two hypotheses that scenario and persona usage can encourage efficient requirement elicitation and shared understanding of requirements within a design team. Based on the research approach presented in Chapter 4, in this chapter we discuss how we design the experiment in order to test these hypotheses. Indeed, there are two main research questions that guide the experiment design process:

Q1: What is the impact of scenarios and personas on eliciting intended user requirements?

Q2: Do the scenarios and personas have an impact on ensuring a shared understanding of the intended users and their requirements among design actors?

In this chapter, the description of how the experiment is designed, and what is the rationale behind the taken decisions during this experiment design process are explained in detail. First of all, the framework of the experiment is presented. Secondly, the design situation, which is worked on, is discussed. Lastly, the adopted process model is demonstrated.

2. Design of the Experiment

As mentioned in the previous chapter, in order to ensure the internal validity, and since it is difficult to cover all the requirements in the field, a laboratory experiment is conducted. The design of the experiment is discussed under three sub-sections: Experiment Framework, Description of the Design Situation and Experiment Process.

2.1. Experiment Framework

To answer the above-mentioned research questions, ideally, what we want to have in the experiment is the same configuration (the same people, context, time, and so on in both experiment groups), so that we can see whether when they use the scenarios and personas we get the desired outcome. Obviously, we can never achieve this goal, where simultaneously the same group of people realizing different tasks. However, we can charge each subject with taking part in each experiment group. That is not just reasonable neither, because taking part in one group, might affect the performance and knowledge in the other one. For example, in the second condition they may improve, because they have had more practice at the first one. They can also surmise the aim of the research, which can cause “placebo” effect (Chapter 4 section 4.1.3).

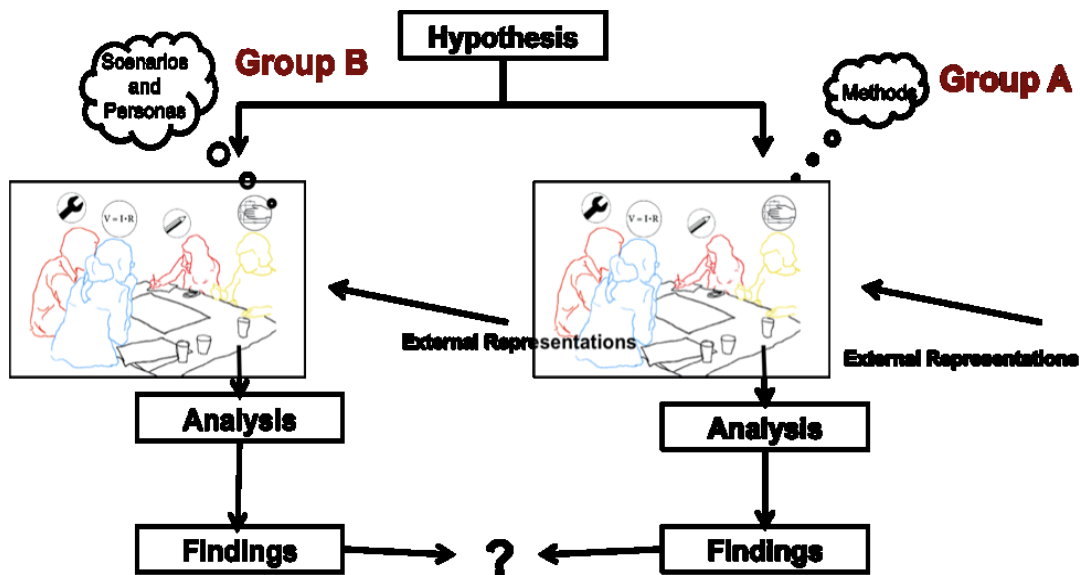


Figure 16: Experiment Framework

Thus, a more reasonable solution is to create two configurations that are as similar as we can possibly make them. If we can be confident that they are comparable, then we can give one group the scenarios and personas as a method and not give them to in the other. Thereafter, we can analyse the outcomes of the groups and compare the findings. As mentioned in chapter 4, the designers’ external representations of the product are accepted as indicators for analysing the design activities. The rationale that we try to cover is then the following: there are two groups that are as similar as possible; while one group (experimental group - Group B) is required to use the scenarios and personas as a method, the other group (control group - Group A) is not (see Figure 16), and their external representations are the real concern of the study.

Since in all other aspects, the two groups are treated in the same way, our assumption is that the differences in the findings between these two groups result from using scenarios and personas.

Furthermore, in order to understand if the subjects progress during the design meeting, we need before and after measures. For example, the group may share understanding of user requirements even before the design meeting. Consequently, the experiment itself consists of three main steps for each group (Steps 3 to 5 in Figure 17 below). Step 4 is the collective meeting. During the steps before (Step 3) and after (Step 5) the design meeting, the subjects are asked to realize individual tasks, whose outputs will be used as a measure. In order to ensure the comparability of findings, the same measure has to be used in these before and after steps (labelled as “Obs” in Figure 17).

In addition to these three main steps, the subjects have to be trained about the tools and methods that they will use during the experiment. A preliminary training step (Step 1) is hence required in order to train the subjects. On the other hand, the subjects also have to be informed about the experiment procedure and timeline and be introduced to each other before the experiment, so that a presentation step (Step 2) is added.

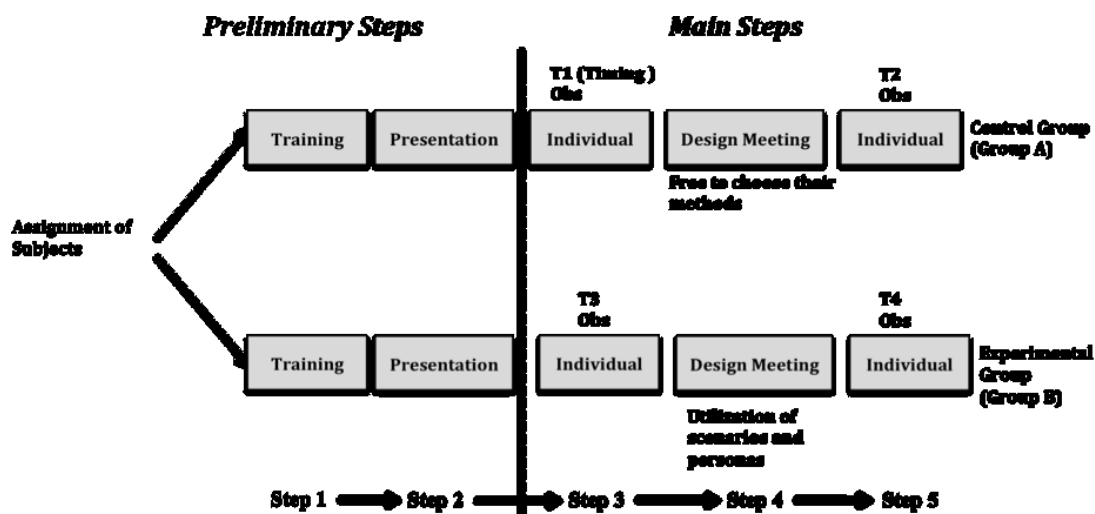


Figure 17: Detailed framework of the experiment

In the following section, the design situation, that we focus on, is discussed in detail.

2.2. The Design Situation

As discussed in Chapter 4 section 3.2, according to Prudhomme et al. (Prudhomme et al. 2007)’s model, a design situation contains four main elements: task, actor, object and environment. By taking this model as a reference, the relevant considerations that are addressed in the experiment for each element are presented.

2.2.1. Object

The industrial product to be worked on is a “digital calendar”. The product idea is chosen from an open innovation platform: Crowdspirit (www.crowdspirit.com). This site allows its visitors to submit new product ideas, commit arguments, and make proposals about product ideas. The aim is to design a new product collectively on an Internet platform. We have three reasons for choosing this design object: 1) We have already an independent corpus on this project obtained from the Internet site for testing the acceptability of the experiment; 2) As subjects have a limited time for achieving the design task, materials have to be simplified. So, we have chosen a product idea that the subjects of the experiment may feel familiar with and contribute to it easily; 3) The idea was pointed out as the most popular one on the site, so that we think that it can be interesting for the subjects to work on it.

2.2.2. Task

The main focus of this research project is the product definition phase. Thus, we chose to construct a design meeting typical to that phase, during which the subjects are asked to elicit the intended users’ needs and to formalize them as a list of functional requirements (Step 4 in Figure 17). This is a face-to-face design meeting and the functional requirements are listed in the form of the Function-Criteria-Metric (FCM) table (see Table 5).

N° :	Designation of the Function	Criteria	Metric

Table 5: The FCM table that is asked to complete

The subjects are supplied with a briefing to describe the design object to be worked on and the tasks to be realized. In the early stages of the design, the design problems are ill defined and less restricted. Thus, as discussed in (Bender et al. 2002), the briefing consists of only verbal and brief description of the target market and a list of preliminary requirements. Moreover, the tasks to be carried out, the available resources and the amount of time available for the work to be done, are described (see appendix 7).

To do the tasks, while members of Group A are free to choose their methods, the Group B is asked to use scenarios and personas. Another discussed issue is the kind of representation media (video, storyboard, text, etc.) that can be used for the scenarios and personas. Because the subjects of the experiment are limited in time, easy to manipulate and to create media like text or storyboards are more employed as discussed in Chapter 3 section 2.2.1. Therefore, the subjects are asked to create the scenarios in written or storyboard format.

2.2.3. Actors

The design actors are the subjects who participate in the study. From now on we use the term subject instead of design actor. Because our focus is to analyse the collective activity, we have to use more than one person. Some previous studies showed that in functional analysis, teams with more than 5-6 people, tend to be divided into small informal groups with only a core of 3 to 4 people doing the real work (Fowler 1990). So, we decide to use 4 subjects in each of the two groups (group A and B).

How to create two equivalent groups is one of the main issues. To deal with the possible problem of non-equivalent groups, we go through the subjects one-by-one and select subjects who are a close match according to their educational level (engineering background), age interval and experience level (note that by experience level we mean if they have a working experience in a company). As discussed in the previous section, the approach adopted in experimental design is to assign people randomly from a common pool of people in two groups. In our case, it is difficult to assign people randomly, because of the availability issue of the subjects. However, because they are already balanced according to the above-mentioned criteria, we assume that we get as close to the ideal as possible. This sampling can be then categorized as Patton's (Patton 2001) purposeful sampling that the information rich cases are chosen for the study (see section 3.1.2 b). All subjects are volunteers and not remunerated.

2.2.4. Environment

As previously mentioned, the environment element is described by the industry, the available technology and project organization. In this research, because the study is realized in a laboratory, the industry is not considered.

The available technology during the design meeting is limited then to the supplied facilities. Thus, we have to ensure that the experiment settings are realistic and have a low impact on the subjects. That is a delicate trade off that has to be taken between realism and control.

During the design meeting, both groups are provided with a table, chairs, board markers, a computer for completing the FCM table and a pad of A3 plain paper. Ferguson (Ferguson 1992) states that: *“Many features and the qualities of the objects that a technologist thinks about cannot be reduced to unambiguous verbal descriptions: therefore, they are dealt with in the mind by a visual, nonverbal process”*. Thus, the subjects are also supplied with some draft papers and pens, in order to allow them to sketch or write freely. The computer screen is displayed on the wall by a video projector to facilitate the discussion. Additionally, Group A is

provided with a whiteboard that they might use to apply the method they choose, while Group B is supplied with another computer in order to create the personas and scenarios. In Group B, they are also supplied with a set of pictures selected randomly from Google's image library (which were rooms of a house, offices and people faces) that might be used for scenario and persona creation. The built scenarios and personas are asked to be presented on Powerpoint slides. Subjects are not allowed to use the Internet during the meeting.

In terms of the project organization, within each group, a manager is chosen to manage the design meeting. The manager role is assigned to a subject according to his/her previous experience on meeting management. The choice of the manager might have a positive or negative effect; however the same effect will emerge in the control group, which makes the comparison possible. The aim is to ensure that the tasks are performed in time. Otherwise, all the subjects have equal rights. A specific document is also prepared for the manager in order to explain his/her role (see appendix 5). The manager is also informed that he/she has no hierarchical power on the group in terms of decision making or taking the floor. The subjects are also trained before the experiment with the aid of a training document (see section 2.3.1.d). Both the training document and manager specific document are sent to the subjects four days before the experiment via e-mail.

The next section explains how the experiment is carried out and how the data are gathered and captured.

2.3. Experiment Process

As discussed in chapter 4, Hicks et al.'s process model is adopted to realize a structured observation. This is an iterative approach that involves five main phases: 1) Monitor 2) Capture 3) Analyse 4) Prepare and 5) Intervene.

In the following, the first two phases of the process model are presented. The third phase will be discussed in the next chapter. The last two phases will be the subjects of the last chapter (Chapter 8).

2.3.1. Monitor

This is the phase, where procedures and instructions are standardized to ensure that the subjects will follow the same procedures; no one gets more or less information and they all perform the same tasks they are asked for during the experiment. Thus, the instructions and all statements used are standardized through a written briefing given out to the subjects at the beginning of each step.

a. Pre-test and Post-test Measures

One of the aims of the before step is to give the subjects some time to think individually on the product idea. Their individual representation of the product will help us to get information about their individual perspectives. The same task is asked after the collective meeting in order to track the evolution of individual perspectives as a consequence of the collective meeting. Thus, the same representation media has to be used before and after the design meeting to represent the product in order to realize the same measure. Two different ways of representing the product idea are confronted:

- **Function-Criteria-Metric table (FCM):** The subjects might be asked to list the user requirements in the form of a function-criteria-metric table. For more information about the function-criteria metric table, see Chapter 2 section 4.5.2. The advantages and disadvantages of the FCM are listed in Table 6.

Advantages:	Disadvantages:

Table 6: The advantages and disadvantages of FCM table

- 5W1H (What, Why, Who, Where, When and How) table: The subjects might be asked to complete a 5W1H table as a common representation media for the user requirements. Below the advantages and disadvantages of this table are summarized (see Table 7).

Advantages:	Disadvantages:
[Redacted content]	

Table 7: The advantages and disadvantages of 5W1H table

As we can see from Table 6, using the FCM table in this step might cause Group B to focus directly on listing the functional requirements and not use scenarios and personas as a method. Moreover, because the subjects complete a FCM table before the collective session, during the collective session they might get stuck with their functional representations and not argue or listen the others' ones to create a common one.

However, as the Table 7 points out, utilization of 5W1H can enable members of Group B to familiarize with scenarios and personas, because these questions provide to define scenario elements Chapter 3 section 2.2.1a. Besides, the question “who?” might orient Group A to create personas unconsciously, but this might be identified through the analysis of the outcomes of the study. If it is the case, the findings of the study won't be acceptable. However, the question “how” must be eliminated to prevent them to focusing on solutions instead of functional requirements. After considering these advantages and disadvantages, a lightened version of the 5W1H table is chosen, which contains only the questions When, Why, Who, What and Where questions.

b. Individual Interpretation of functional requirements

This is an individual task. The aim is to see how each subject interprets the functional requirements individually. The hypothesis is that even though they create the FCM table collectively, they might keep their own perspectives on the functions in terms of the importance. Thus, after the collective meeting, the first task asked to the subjects is to rank the 5 most important functions from the FCM table, which is completed collectively. They are also asked to give a relative weight to each function in the form of percentage (total percentage is supposed to be 100).

c. Interview

Once the second 5W table completed, an interview is conducted with each subject individually. There are three reasons for conducting these interviews (see appendix 10 for the interview questions):

- to verify if the subjects agree or not with the group results, and if they are aware of their agreements. Thus, the subjects are interrogated about their individual perspectives on the FCM table completed collectively and their individual ranking lists. They are also asked to comment on the group's perspective, whether they think that the other subjects will answer in the same way. Finally, they give a general description of the product.
- to get some commentaries and critics on the proposed methods (scenarios and personas) and their effectiveness for eliciting and formalizing user requirements.

d. Training the subjects

In order to familiarize the subjects with the methods that will be used during the experiment, we have to train them on these methods. Two possibilities of making the training are compared and the most appropriate one is chosen:

- **Training Session:** A training session might be organized, during which the subjects can be informed about the design methods and be trained on a similar design task by using these methods. The main advantages and disadvantages of undertaking a training session are discussed in Table 8:

Advantages:	Disadvantages:

Table 8: The advantages and disadvantages of a training session

- **Training document:** A training document might be prepared and sent to the subjects a few days before the experiment. The document can explain the design tools and give examples of their usage. The main advantages and disadvantages of using a training document are summarized in Table 9:

Advantages:	Disadvantages:

Table 9: The advantages and disadvantages of the training document

By comparing the advantages and disadvantages of these two possibilities, the solution of training the subjects by a training document is chosen. One of the main reasons is that it is difficult to ensure the presence of each subject for the training session. In the case that one or more subjects are not present in the training session, a new training session has to be

organized. However, this might cause a history threat in terms of the internal validity. For example, the subjects, who have taken the previous training session, might be more mature in terms of the method, because they will have much time to train themselves. The choice of training type may have a positive or negative effect on the subjects. However, they should be manifested equally in experimental and control groups, which certify the comparability of the findings.

In the training document, in order to clarify the methods, each of them is explained through a similar design exercise: the design of new bike lock. The definitions of scenarios and personas are also described for the subjects of group B. Based on the scenario-based framework presented in Chapter 3 section 2.3.2, two storyboards are also given as an example; one of them represents a “problem scenario”, and the other one an “activity scenario”. See appendix 4 for the training document.

e. Presentation

Just before the experiment a presentation is realized to give general information about the experiment steps and timeline. Furthermore, the experiment subjects are introduced to each other. Subjects are not informed about the aim of the project in order to prevent from a placebo effect. They are told that their collective activity would be observed and recorded (video and audio) as a part of the study. They are asked to complete a video consent form in order to check if they consent to be observed and recorded (see appendix 3). After the experiment, a presentation is also given to explain the research goals and to answer to their questions.

f. Experiment Timeline

Another important dimension for the experiment design process is to determine the time necessary for each step. A preliminary study was conducted with industrial engineering students to measure the necessary time for the design meeting (step 4). Four engineering students were asked to perform the functional analysis of a product idea (the idea that is going to be used for the experiment) and list the functional requirements by using scenarios and personas. The students created scenarios, but did not have enough time to list the functions in the form of FCM table. Hence, this preliminary study revealed that 1 h was insufficient to realize the whole deliverables asked. Hence, total time is extended to 1h and 30mn: 1h for group working, then the intervention of the observer in order to remind the time left, and last 30mn for completing the deliverables. On the other hand, the time periods of the earlier steps are defined according to the prior experiences of the researchers. Figure 18 shows the timeline of the experiment.

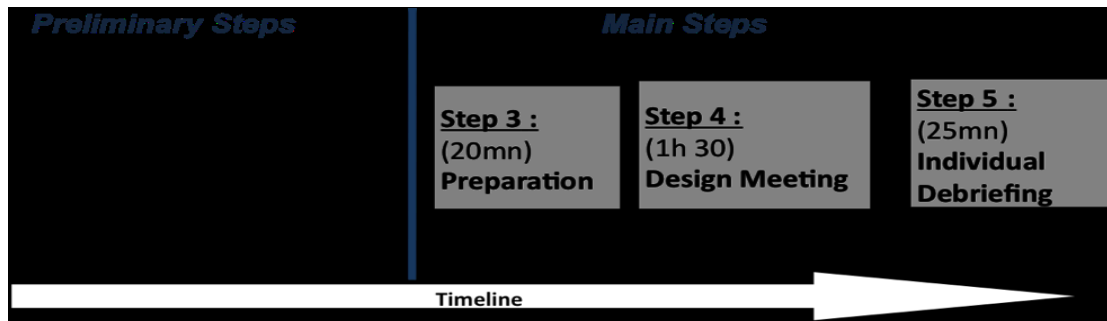


Figure 18: The timeline of the experiment

2.3.2. Capture

In the capture phases, two main questions are answered: “what to capture?” and “how to capture?”.

a. What to capture?

The data to be captured in each step are now detailed. Figure 19 summarizes the documents supplied to the subjects (inputs), the tasks, the timeline and the expected outputs for each step of the experiment for the group A. Group B also follows the same process with the exception of step 4, during which they are also asked to create scenarios and personas and deliver them as an output.

As mentioned previously, at the beginning of each step a briefing is furnished, which describes the task to be realized, the duration of the step and the documents to be produced. The outputs of each step are captured in a systematic way. In the following, the list of the data that are captured in each step of the experiment is given.

- Step 3 (20mn): the 5W tables completed individually are captured in this step (see Appendix for briefing).
- Step 4 (1h 30mn): the design meeting is audio and video recorded.
- Step 5 (25mn): This step is divided in three sub-steps:
 - 1) Step 5-1 (5mn): The individual ranking tables of the subjects are captured (see appendix 8 for the briefing).
 - 2) Step 5-2 (10mn): the 5W tables completed individually are captured (see appendix 9 for the briefing).
 - 3) Step 5-3 (10mn): The interviews are audio recorded (see appendix 9 for the interview questions).

In addition to this data, the intermediary objects that might be used or created in each step of the process are also captured.

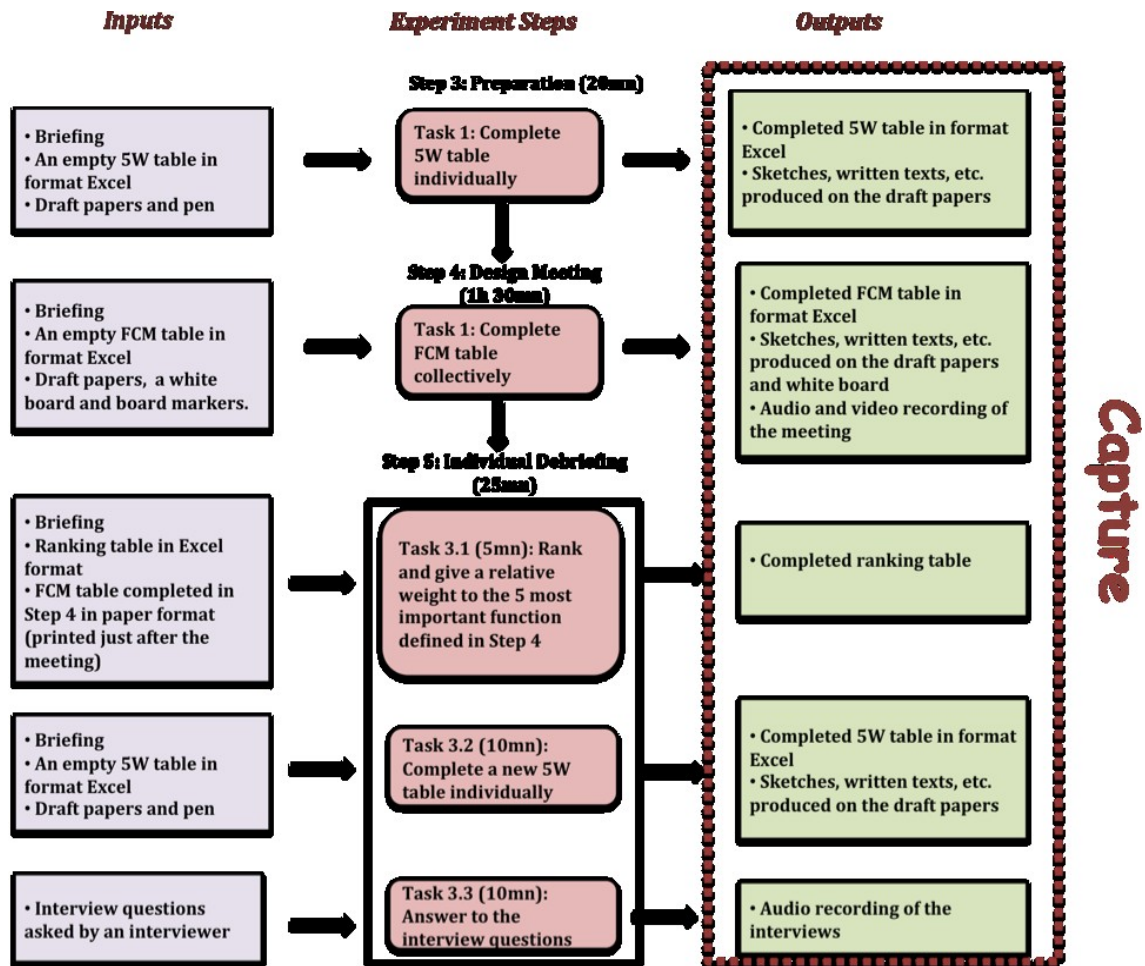


Figure 19: Experiment Protocol-Group A

To summarize, in the capture phase, five main types of captured data are captured: 5W tables gathered from pre-test and post-test, video recording of the design meetings, ranking tables of the subjects, interviews, scenarios and personas (in group B) and all the intermediary objects produced or used during the whole process.

b. How to capture?

- **The steps before and after the design meeting (Step 3 and Step 5):**

During the before and after steps of the design meeting, in order to realize their individual tasks, each subject is provided with a computer. The subjects are located in the same room in a position, where they cannot see other computers (see Figure 20). They are not

allowed to discuss about the task or use the Internet. Two observers are also present in the room to reply to the questions and verify if the subjects respect the experiment procedures.



Figure 20: Environment for the Step 3 and Step 5 of the experiment

Two interviewers conduct the interviews in parallel sessions in order to reduce the waiting time of the subjects. In order to make the interviewers follow the same procedure, a structured open question interview is carried out (Coolican 2006). Interviewers might expand the question if the subjects cannot understand. However, they are not allowed to ask new questions or change the order of the questions. Hence, the standardization of the interview process and also reliability and validity of measurement are acquired.

- **Design meeting (Step 4):**

Any or a mixture of the data-gathering devices can be used to record the chosen elements, such as hand-written notes, audio and/or visual recording and measuring equipment. The advantage of video recording is that the activity recorded on the video can be reviewed and analysed after the event from a variety of perspectives. The video recording also enables to identify who is speaking and in what order, which facilitates the realization of the transcript of the verbal dialog of the subjects. Furthermore, it provides the information about the interaction of the subjects with the intermediary objects; detecting what they write or sketch during the session, how they use the supplied objects, etc. Thus, video recording of the design meeting is chosen as a data-gathering device. Another question is how to record the interviews of the subjects. The interviews of the subjects are conducted individually and the subjects are not supposed to write or draw anything during the interviews. As a result, instead of video recording they are merely audio-recorded.

Thus, an experiment room is prepared and equipped with video recording facilities. The experiment room is a usual meeting room, where the subjects can sit down and discuss around a

table. Multiple views of the design activity need to be captured to have an integral vision. Three movie cameras are installed to capture different views:

- a close view of the subjects as a whole when sitting at the table, to capture who is talking, to whom, in what order.
- a view of the whiteboard, to capture what is written or drawn on the it;
- an overhead view of the table to capture the objects produced or used during the session.

Figure 21 shows the experiment room view of group A. For group B, the same experiment setting is used. However, one movie camera is removed (the one, which is recording the whiteboard), since in this group the whiteboard is not used.

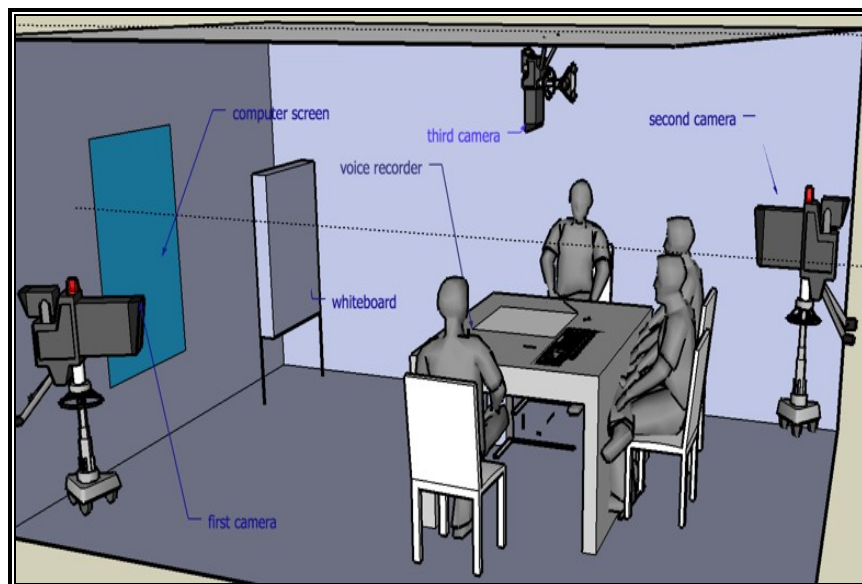


Figure 21: (Group A) Experiment room view

Preliminary tests showed that the voice captured through the cameras was incomprehensible. Consequently, a voice recorder is placed on the table. On the other hand, our previous experience with video analysing in workshop DTRS7 (Arikoglu et al. 2009) showed that the overhead video capture of the table is not effective to detect the written or drawn objects, when the subjects use usual pens or pencils. Thus, the subjects are asked to use board markers instead of pen or pencils. Tang (Tang 1991), discusses that passive cameras are less distracting than having a cameraperson in the room aiming and focusing the cameras. We have also noticed in workshop DTRS7 workshop's data that the subjects have forgotten the presence

of the cameras during the meeting, which were also passive. Therefore, the cameras are fixed and not moved or repositioned during the session so as not to disturb the subjects.

Similarly, the observer and the recording equipment are situated in a neighbouring room that the subjects could not see, in order to obtain more genuine behaviour (see Figure 22). The subjects then feel less of a target and hence more relaxed (Coolican 2006). In the Grenoble experience (see the list of experiments carried out in Chapter 6 section 2), a one-way mirror, which acts as a mirror for the subjects but as a window for observers, separates these rooms. The observers observe subjects behind the mirror to check whether the instructions are followed and procedures are respected. In the other experiences, the observation is done through the video-mixer screen, where all the cameras views, computer screens and audio are mixed together. Once the experiment starts, the subjects are on their own. They are informed that they are free to get up and move around the experiment room. An observer only interrupts once to inform the time left (30mn before the end of the meeting).



Figure 22: Real-time observation and capturing (Grenoble)

During the meeting the three camera views and the computer screen are recorded and mixed into one 4-PIP (four pictures in picture) combined view (see Figure 23). The group B 4-PIP combined view contains two computer screens and two camera views.

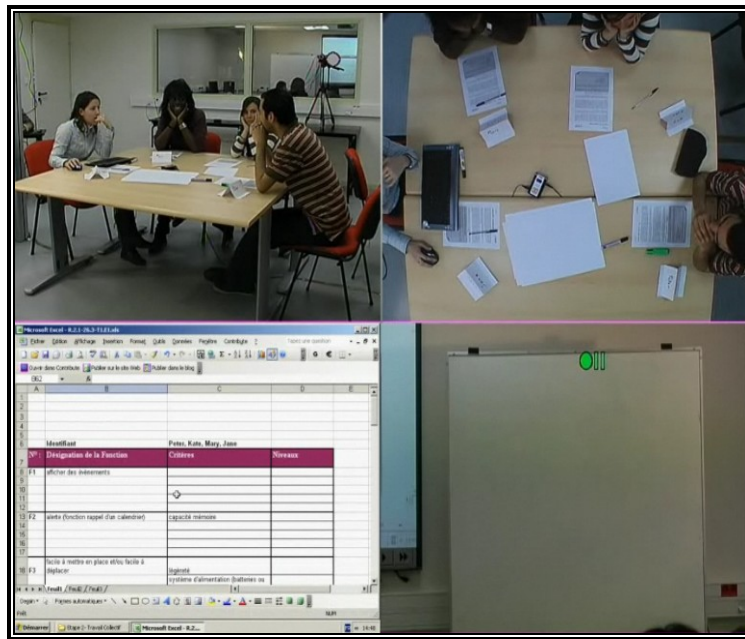


Figure 23: (Group A) 4-PIP

3. Concluding remarks

In this chapter we have discussed the way the experiment is designed. In other words the experiment design process and the rationale behind it are explained in detail. The main point is to be aware of possible shortcomings and consider them while interpreting the findings.

Table 10 summarizes the possible threats for the internal and external validity of the experiment. The sign “+” symbolizes that this threat is considered during the design of the experiment and its effect is prevented to ensure validity, while as the sign “-” labels just the opposite. Finally, the sign “?” means that the threat might have a positive or negative effects on the experiment, but these have not been considered for the experiment design. It is important to indicate that, even if these threats have an effect, since they will affect both groups, it won’t avoid the comparability of the groups’ results. In the following, the way that the table is completed is expanded.

Even if the groups are not distributed randomly, the addition of a control group greatly reduces greatly the ambiguity of interpretations. Moreover, as Campbell and Stanley (Campbell and Stanley 1966) mention in non-equivalent control group design “*the main effects of history, maturation, testing, and instrumentation, in that the difference for the experimental group between pretest and posttest (if greater than that for the control group) cannot be explained by main effects of these variables such as would be found affecting both the experimental and the control group*”. Moreover, in our case the timeline is too short to observe maturation and

mortality effects. However, the groups are supplied with the same experiment layout with the difference that group A is provided with a whiteboard, while as group B with a computer in order to apply their methods, which might have positive or negative effects.

In terms of regression, if the groups are chosen from the people for their extreme scores on pre-tests, then there might be a regression effect on the findings rather than treatment. However, in our case the groups are constructed so as to be as similar as possible. The pre-tests of the groups have to be analysed to check the regression effect. Lastly, due to the selection of the groups, the other threats might be taken as the outcome of the independent variable.

On the other hand, in terms of the external validity there are not multiple treatments that might influence the effect of each other. However, it is difficult to talk about other threats that might affect external validity.

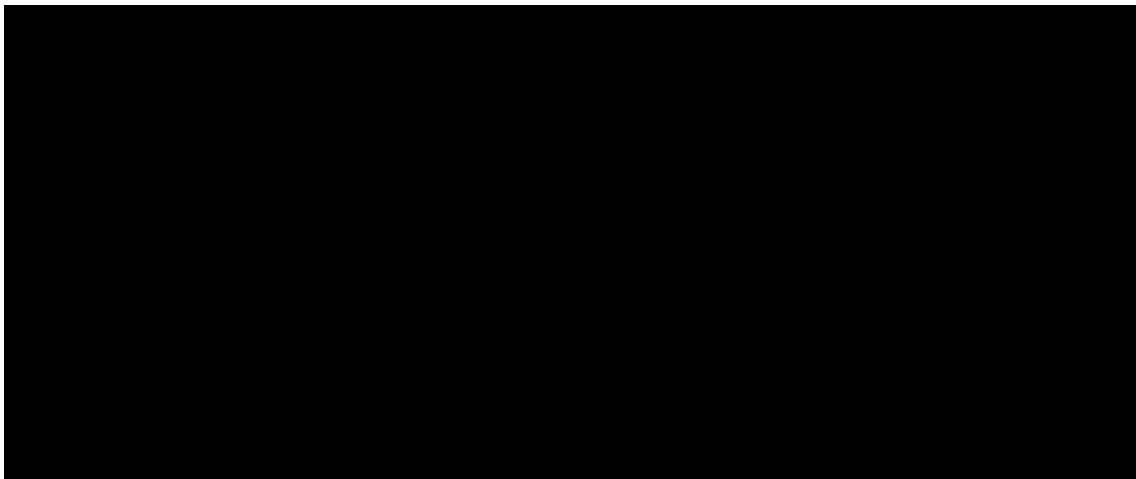


Table 10: The threats for the internal and external validity (adapted from (Campbell and Stanley 1966))

Moreover, because the study is realized in a laboratory setting, it is difficult to talk about ecological validity. However, the environment created in the laboratory respects to the common meeting environment. The subjects were informed that they are free to move and behave in the way they want in the room in the interest of encouraging natural behaviour. On the other hand, the same experiment is carried out with industrial partners, to eliminate the fact that the students might not represent the real engineers with the working experience in a company. Two other main criteria, which are used to evaluate the experiment's replicability and reliability, will be discussed in Chapter 6.

In the next chapter, the analysis phase is presented. The indicators that are used to analyse the gathered data are explained in next chapter, but the findings will be presented in Chapter 7.

Part 3- Results

The experiment study has been conducted four times. In order to ensure its replicability, the same study is carried out in three different laboratories with the same protocol prepared both in English and French. As a result, seven co-located design sessions are captured with the duration of one and half hour for each. Some indicators are proposed, which are used to analyse the outcomes of these studies in order to deal with the research questions (Chapter 6). The findings of the analysing process are then presented and interpreted (Chapter 7). To summarize, Part-3 presents the way that the gathered data is analysed, and also discusses the findings of these analysing activities.

Chapter 6 Analysis

This chapter describes how the outcomes of the experiments are analysed. There are three main purposes of the analysis: 1) to ensure the replicability of the experiment, 2) to answer the research questions, and 3) to ensure the reliability of the experiment data and the reliability of the findings.

1. Introduction

As mentioned in the previous chapter, there are two main research questions that are going to be dealt with, in the analyse phase. In this chapter, before focusing on these questions, first of all we demonstrate how the replicability of the experiment is ensured. Thereafter, we demonstrate the way that reliability of the gathered data and reliability of the findings are evaluated. Finally, the indicators that are used to answer the research questions are presented. These indicators are discussed under the two main research questions: problem of understanding between design actors and problem of eliciting intended user needs. It is important to warn that in this chapter, we only explain the way that the measures are realized; the findings will be presented and interpreted in the next chapter.

2. Replicability of the Experiments

In total seven design sessions were conducted. The same experiment protocol followed for each of these sessions, as described in the Chapter 5. Table 11 summarizes the conducted design sessions, which are categorized according to the location of the experiment, the spoken language during the meeting, the background of the subjects and the date.

As we can see from the table, the same experiment study was conducted four times. While Exp-1 and Exp-4¹¹ were conducted in the same laboratory, Exp-2 and Exp-3 were carried out in different laboratories based on the same protocol (prepared both in English and in French). Moreover, in Exp-3, differently from other ones, the researchers who designed the experiment were not present for the experiment run-up. Different researchers were charged with the experiment realization by following the given protocol. Consequently, there is no doubt on the replicability of the experience.

¹¹ Additionally, in Exp-4, the experienced mechanical engineers are integrated to the experiment.

Session Name	Location of the Experiment	Language	Group Background	Date

Table 11: Summary of the conducted design sessions

3. Reliability of the Gathered Data

The aim of this section is to check the reliability of the gathered data. This is related to the questions:

- How to be sure that group A does not also use the scenarios and personas? Subjects might some how know these methods and might apply them during the design meeting.
- How to be sure that group B uses these approaches during the meeting? Subjects might refuse to use these methods, even if they are asked for.

To answer these questions, we carry out a two-stage analysis. As a first stage, we come up with a global analysis in order to become familiar with the data and to have an overview of the meetings. Thereafter, a deeper analysis leads us to identify the orientation of the discussions within the group. In this detailed analysis, we focus on the verbal communication of the subjects. Our assumption is that, in the group which uses scenarios and personas as a method, the discussions will be more “user and usage” oriented. However, in the group, which does not use them, the discussions will be more “product” oriented. In the following, the way that the analyses are realized is detailed.

3.1. Global Analysis

The first step of the global phase is transcribing the videos. The transcription allows on the one hand, more thorough examination of what people say. On the other hand, it opens the data to public examination, who can evaluate the analysis of the data that is carried out by the original researcher of the data. A professional company realizes the transcriptions. The format to be respected is based on literature review (Coolican 2006; Tang 1991) and our previous

experiences (Prudhomme et al. 2007; Boujut and Blanco 2003). Here is the list of the respected characteristics of the transcripts (see Figure 24):

- Verbatim: respects exactly what the subjects say
- Includes some non-linguistic features such as: laugh, pause etc.
- Contains line numbers and timing (with a 1mn time interval)
- Includes lines for each subject. Subjects' real names are hidden; instead they are called as SP1, SP2, ...etc.
- If some words used by the subjects are not understood, the label "inaudible" or "unclear" is used to show that there are missing words.

Ligne	Temps	Locuteur	Discussion
661		SP3	Manual too ... or manual ...
662		SP1	It should allow all of it or ..?
663	0:53:00	SP3	I mean manual information, no manual decision-making ...
664		SP2	Yes, scale of ...
665		SP3	... and automatic decision-making. It's 1-0, 0-1.
666		SP1	I think it should allow for the whole scale, so from manual to semi-automatic
667			to automatic.
668		SP3	Yes, yes, we have to.
669		SP2	Well, that's how we're going to measure how good an automation it is.
670		SP1	Or how much information ...
671		SP4	So, what value do you want to go for? Do you want to go for all [unclear],
672			you want to be able to do it manually, semi-automatically and automatically.
673			Is that what you're saying?
674		SP1	I would say you should.
675		SP3	I mean everything is manual and one is everything is automatic, [inaudible]
676			making forces is automatic.
677		SP1	But do we want to be at zero or one or across the whole range?
678		SP4	You're saying across ... you won't be able to do any one of those. [Yes].
679			Because I would say it's going to be done automatically. [Okay].
680		SP1	Well, it's an idealistic system anyway, so let's move on.
681	0:54:00	SP4	Speed or tongue.
682		SP2	Yes, timing of it.
683		SP1	If it's automatic?
684		SP2	Well, it would be zero then, wouldn't it?
685		SP4	Well, no ...
686		SP2	Not necessarily, yes.

Figure 24: Video transcript sample

Thereafter, we try to have a global view on the meeting. Our aim is to become familiar with the data and to create a workable representation of it. We look into discussion topics, artefacts, organization of participants (formal authority hierarchy), the way they express their ideas, etc. To fulfill this task, we analyse and understand the transcripts of the meeting dialogues. We also view and review the video recording of the meetings to have a complete view of the meeting; the way they use the artefacts, their gestures and mimics, etc. As a result, we also try to complete the missing parts of the initial transcripts (the parts that are indicated as unclear and inaudible) as much as we can.

We make the assumption that transitions between meeting phases take place in the form of changing topics or the structure of communication between designers. Consequently, we attempt to define the main phases of the meeting, by focusing on the interaction between designers and the topics of their discussions. Hence, the global analysis enables us to have the

time interval of different phases of each meeting. For example, one of the phases can be time interval, during which the subject's discussion are more focused on persona building.

3.2. Detailed Analysis

There are two main assumptions that guide the way that we control the acceptability of the gathered data:

- Assumption 1: The way they express the user requirements in each group should be different.
- Assumption 2: In contrast with group A, in group B subjects should create and use personas.

Based on these assumptions a coding schema is created and videos recording of the meetings are coded. In the following, the rationale behind these assumptions, the coding schema, coding process and the interpretation of the findings are discussed.

3.2.1. Creation of the Coding Schema

In the following, the creation of the coding schema is presented.

a. Expressing the user requirements

As discussed in Chapter 3 section 2.3.1b, in usage scenarios, the user requirements are expressed in terms of the users actions, in other words the way they use the product. User requirements extracted from the scenarios then consist of objects, actions and contexts. User requirements then are discussed as the “actions” of the user. For example, a user requirement created for a personal digital assistant (PDA) type telephone:

Call (action) a person (object) directly from an appointment (context)

On the other hand, as discussed in Chapter 2 section 4.5.2, user requirements might be expressed by particular functional requirements, which are usually depicted by a verb-object phases. The verb defines the required action where as noun tells what is acted upon, such as for a car seat one of the product function might be “support (verb) head (object)”.

Hence, two different ways of expressing the user requirements are then defined: in terms of the user point of view and in terms of the product point of view. In the following, we explain the grammatical structure of the sentences used to describe the user requirements in both ways:

- In terms of the user point of view. The way that user will act to satisfy their needs, which we label as “fragment scenarios”. The sentence structure of the fragment scenarios are: User + Action verb+ [Object (and/or Context)], Product+ Action verb in passive form + [Object (and/or Context)] or Action verb in passive form.
- In terms of the product point of view. The way that the product will act in order to satisfy the users’ needs, which we label as “product functions”. The sentence structure of the product functions: Product + Action verb + [Object (and/or Context)], User + Action verb in passive form+ [Object (and/or context)] or Action verb.

It is important to open a parenthesis here to clarify that the term “action” can be used in a broader and narrow sense. In a broader sense, what we call “user action”, refers to the *desired effect of the user behavior* and in a narrow sense the *behavior of the user*. For example, the previous PDA example: “call a person directly from an appointment”, is a desired effect of the user actions. Then, the user behaviors for the desired effect can be listed as: click the “menu” button, search for the person name, etc. In our coding process, the word action is used in a broader sense both for the fragment scenarios and product functions (which was already discussed in Chapter 2 section 4.5.1).

To conclude, our assumption is that during the design meeting, while discussing around the user requirements, the subjects of group A should mostly express themselves in the second way, while the subjects of group B in the first way.

b. Persona creation and use in groups

Ideally, group A won’t use the persona approach, while as the group B is asked to create and use personas. Thus, in order to ensure the reliability of the data we have to verify the persona creation and use in each group. By persona creation, we mean the creation of user archetypes, giving them names, age, details etc., and by persona usage we mean the discussing of their connection with the product, defining their needs, etc. (see Chapter 3, section 3).

c. Coding Schema

In the light of these assumptions, a coding schema is constructed. First column of the Table 12 shows the defined categories, while as the second column describes the context of each category. Finally, the last column gives some examples of sentences that fit with this category. It is important to note that the creation of the coding schema was an iterative process: the video recordings of the meetings were coded through coding schema and the coding schema

was completed through video recording. Hence, the passive forms of the verbs have been considered after the preliminary coding. The coding process is detailed in the next section.

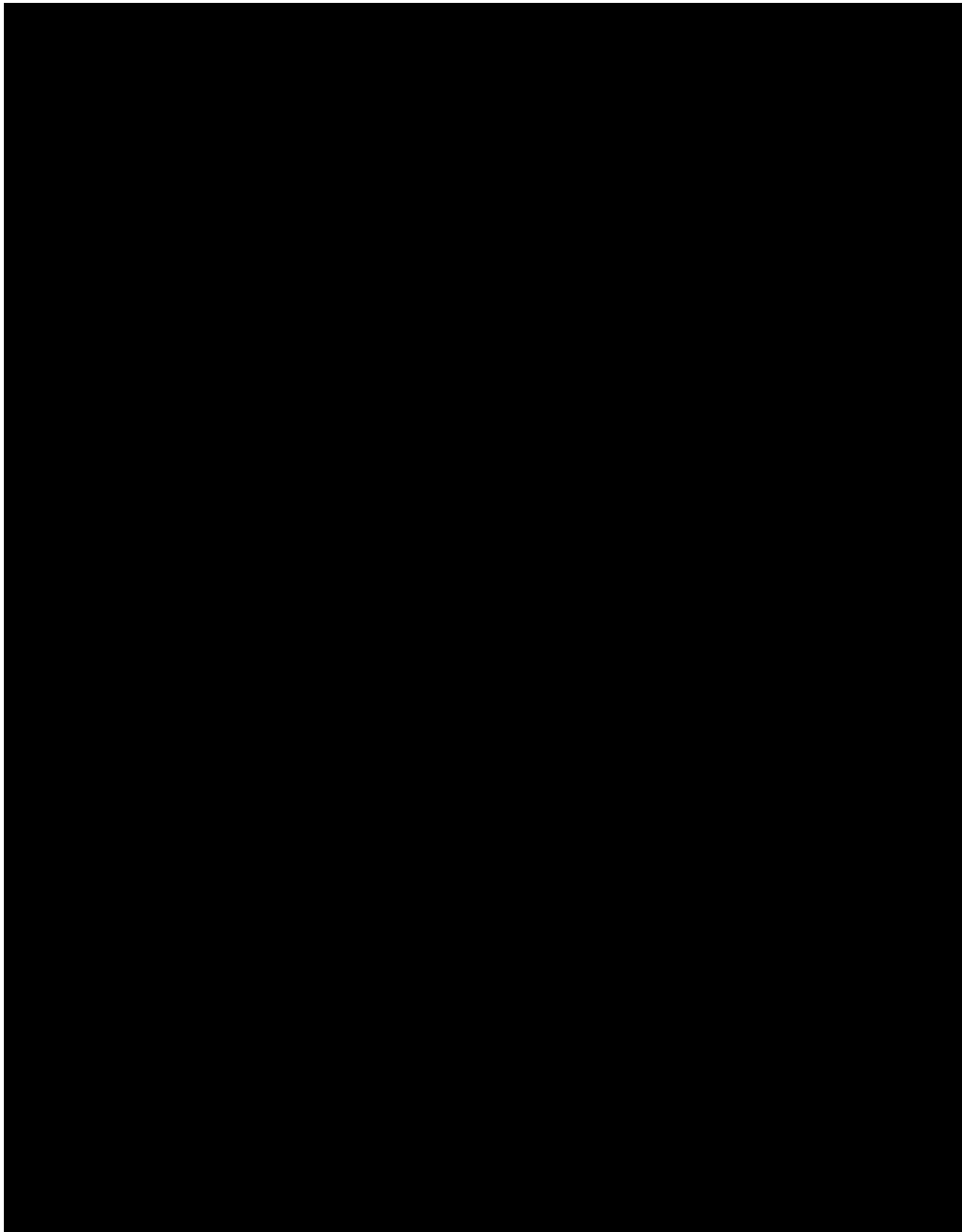


Table 12: Coding schema for the data validity analysis

3.2.2. Coding process

Video annotation tool VCode is used to perform the coding of the meetings based on the previous coding schema. VCode is an open source tool to aid in video annotation, which makes it possible to perform the coding synchronously while the film is running. It allows

annotating both the time when the event takes place and its duration. In order to get more information about the tool (Hagedorn et al. 2008) can be read.

Each sentence in format *fragment scenario* or *product function*, what time and by whom it is told, is coded on the video (see Figure 25). Transcriptions of the meetings are useful resources to note each sentence while coding. Additionally, the time periods during which the personas are created and used are coded. In other words, the starting time and the duration of the discussions of the subjects around personas are coded.

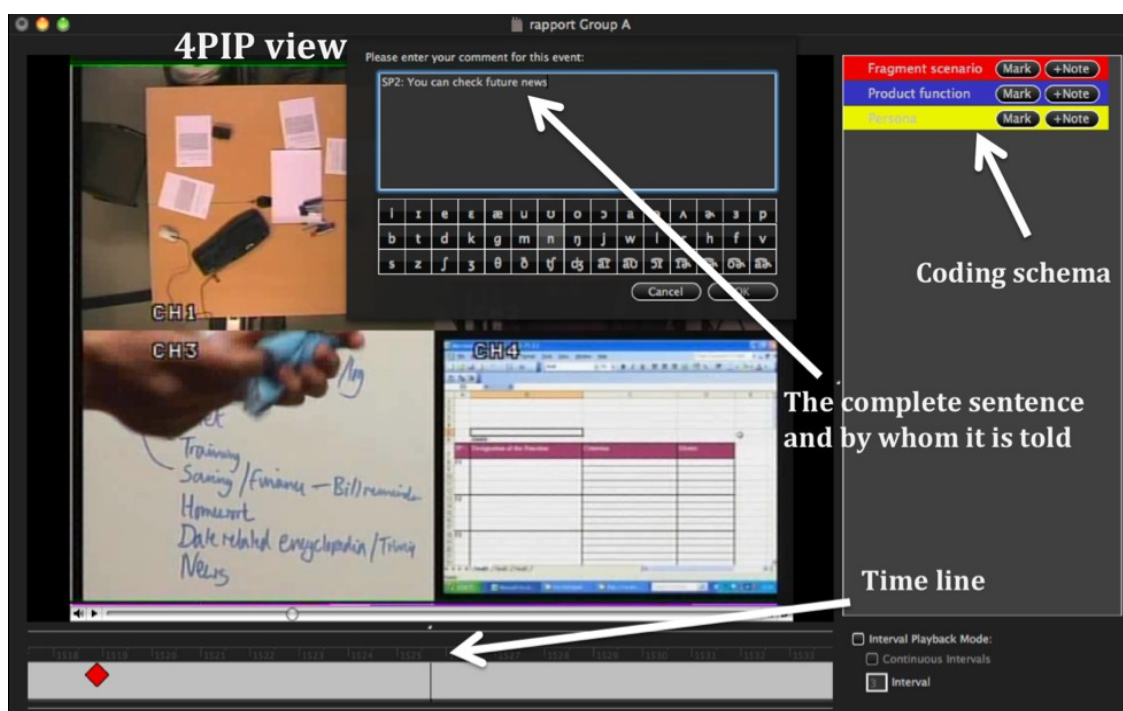


Figure 25: Coding process with VCode

Once the coding is realized, the results can be exported in spreadsheet software. Table 13 shows an example of one coded fragment scenario exported from VCode in Excel format.

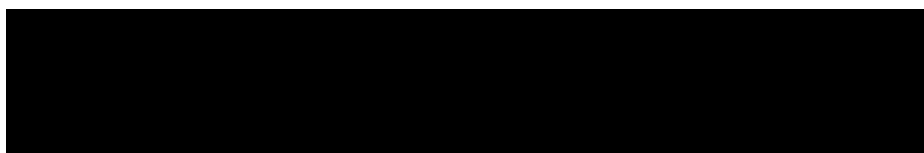


Table 13: Example of a coded fragment scenario exported in Excel format

In order to standardize the coding process, procedures to be followed while coding are listed:

- The action words that are separated by a conjunction (such as and, or, etc.) are accepted as a part of the same sentences even if they may signify different actions.

Ex: “It becomes a fun way for organizing and educating and facilitating time management”

- If a sentence is constructed by more than one subject, all the subjects participating to its construction are noted.
- If two sentences are separated by a conjunction (such as and, but etc.), they are accepted as two separated sentences.

Ex: “They don’t necessarily have access to it but he can send it to them”

- While discussing about the personas, they usually used pronouns like “he” and “she” instead of their names because they were all aware of whom they were discussing about. While coding the fragment scenarios, we have also coded the name of the persona or the object they are talking about.

Ex: “She (Emily) can see and touch them (photos or cuttings) and play with that (calendar)”.

3.2.3. Interpreting the Findings

In both meetings, firstly, the number of sentences that fit into the first and second categories are counted and compared. Secondly, contributions of each subject, in terms of the number of created sentences in each category are also analysed. Finally, the numbers of personas created and total time spent on them in each groups are evaluated. As a result, for the reliability of the gathered data, the following conditions have to be attained:

- In group B the numbers of sentences, which fits into the first category, has to be more than those in the second one, while as in group A exact opposite.
- In group B, it is expected that all of the subjects generate sentences of the first category during the meeting. Because, if all the contributions in terms of the first category sentences are coming from the same subject, that disproves the idea that they use scenarios as a group method.
- In group B, subjects have to create personas and should spend considerable time on them. For example, if they just create one persona at the beginning of the meeting, spend thirty seconds on it and never create or use any more personas again, we cannot really say that group B uses persona as a method.

4. Evaluating the reliability of the gathered data

In order to ensure that while group B used scenarios and personas, group A did not, we conducted an analysis on the video recordings of the meetings. Because of the time factor, we could not realize a deep analysis in all the video recordings. Thus, we gave our attention to the second experiment (Exp-2). The main advantage regarding our objectives was that in this experiment, group B seemed to be richer than the others, regarding the number of scenarios and personas involved in the interactions. This was a key aspect, as we have chosen to focus on these methods for our research project. In the following, the results of the two-step analysis described in the previous section are presented.

4.1.1. Global analysis

We start by discussing the findings from the global analysis of the video recordings of the experiment groups. First of all, the sequences of the meeting phases are presented, which were quite different in each design meeting. Thereafter, we discuss the way they were organized within the group.

a. Group A

In Group A, there were four main phases (see Figure 26). In phase 1, they listed their general ideas about the product on the whiteboard. In this group, they decided to focus on two user populations: a family and a work group. They went ahead with defining the needs of the family and continued to take notes on the whiteboard in phase 2. In phase 3, they carried out the same procedure for the work group. Finally, in last phase they completed the Function-Criteria-Metric (FCM) table.

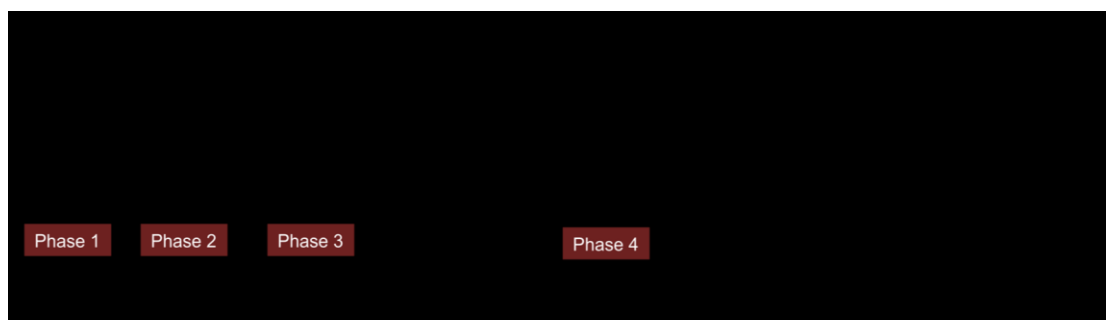


Figure 26: Phases of the group A meeting (Exp 2)

In this group, we observe that the manager of the meeting has a great influence on the other subjects. For example, during the transition from phase 1 to phase 2 (in the 7th minute of the meeting), the manager asks to other participants, with which user population they could

start: “Which one then? Work or family? Work [okay]”. However, without waiting the answers of the subjects, he decides that the user group that is firstly going to be focused on is the work group.

b. Group B

In group B, six different phases are observed (see Figure 27).

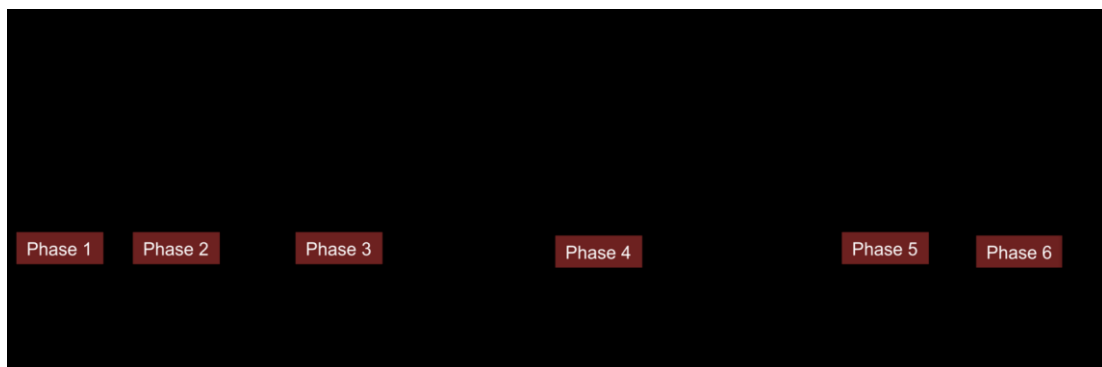


Figure 27: Phases of the group B meeting (Exp 2)

In phases 1, the subjects briefly share their general ideas about, how they imagine the product. Similarly with group A, they also decide to focus on two user populations: a family and a work group. In phase 2, they create the Personas of a family, which consists of four main Personas: mother, son, daughter, and grandfather. They describe each Persona (a photo of the Persona and his/her characteristics) on a Powerpoint slide (see Figure 32). In phase 3, they follow the same procedure and create three new Personas, who are the members of the work group. The mother of the family is also a member of this work group. Afterwards, in phase 4 and phase 5, they define the functional requirements related to each persona; respectively the family personas and the work group personas, and they complete the FCM table. Finally, in the last phase, they discuss about what can be missing on the FCM table, and simultaneously they complete the missing parts.

In this group, the transitions between phases are done through a common agreement between the group members. Either the manager of the meeting or one of the other participants starts the new phase after seeking the approval of the others. For example, to go from phase 1 to phase 2, the manager asks, if they could start with the family or the work group. Once he got the confirmation, the group starts to create the personas of a family. This question was the indication of the starting point of a new phase.

To conclude, the global analysis shows that the structure of the each design meeting is different. In contrast with group A, in group B, the manager of the meeting is moderate and the

transition between phases are done through a common agreement between group members. We can also notice that, due to the fact that group B is asked to use the scenarios and personas, the subjects organize their meeting around these methods. That can be accepted as a proof that the participants of this group use these methods during the meeting. The findings of the detailed analysis are discussed in the following.

4.1.2. Detailed Analysis

As discussed in section 3.2, in detailed analysis we analyse which formalization category they use, while discussing about the requirements¹². The numbers of personas built in each group and the time spent on them is also verified.

a. Group A

Figure 28 shows, which kind of formalization the subjects used, individually and collectively, while working on the user needs. As we can notice from the figure, in this group the requirements were mostly formalized as product functions. Only the subject 3 used more frequently scenario fragments to talk about the user needs. The figure also points out that subject 4, who was the manager of the meeting, was more effective in terms of the number of expressed functional requirements, compared to other group members. He stated a total of 81 functional requirements. While 15 of them were in the form of scenario fragments, 66 of them were product functions. Subject 1 followed him with in total 67 functional requirements; 11 scenario fragments and 56 product functions. However, this number does not signify the real number of elicited requirements. Because, while discussing, the subjects might have expressed many times the same functional requirement.

¹² It is important to note that, during this coding process, we focus on the formalization styles, not the requirements themselves. That means the same requirement might be expressed many times with the same or different formalization categories.

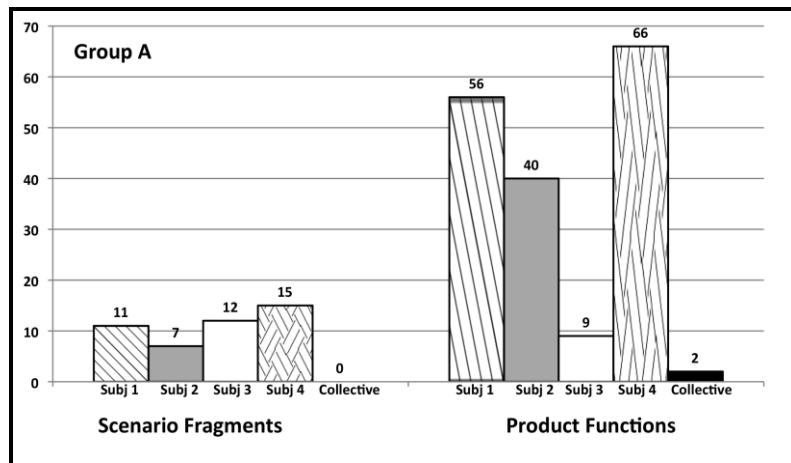


Figure 28: Coding results of group A (Exp 2)

b. Group B

Similarly with Figure 28, Figure 29 shows which kind of formalization each subject and individually and collectively used, while expressing the functional requirements in group B. As we can see from the figure, unlike group A, in this group the requirements were equally formalized as product functions and scenario fragments. In contrast with other group members, subject 1 mostly communicated the functional requirements in the form of product functions. Similarly with group A, the manager of the meeting, was more effective in terms of the number of expressed functional requirements with 132 requirements; 65 in the form scenarios fragments and 67 product functions.

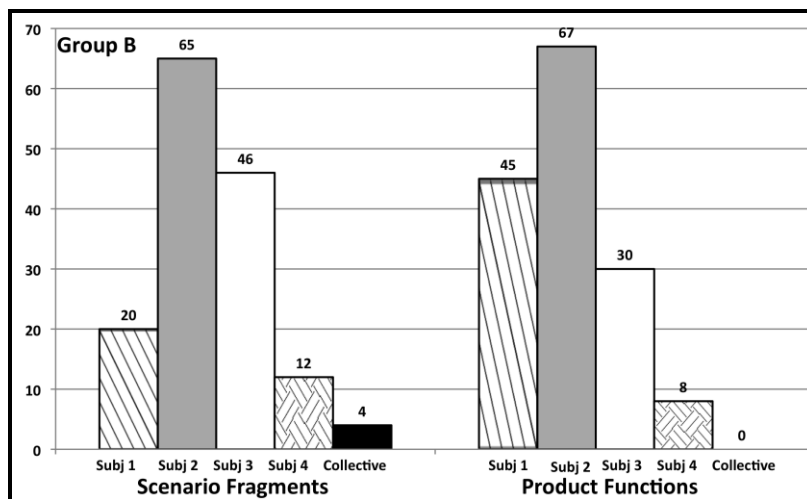


Figure 29 Coding results of group B (Exp 2)

c. Comparison of Group A & B

Figure 30 presents the cumulative number of requirements communicated in the form of fragment scenarios and product functions in each group. The x-axis of the histogram shows the

timeline of the meeting. In group A, a total of 218 functional requirements; 45 fragment scenarios and 173 product functions were expressed. In group B the total was 297 functional requirements, 147 fragment scenarios and 150 product functions. We can conclude that group B used scenarios much more than group A.

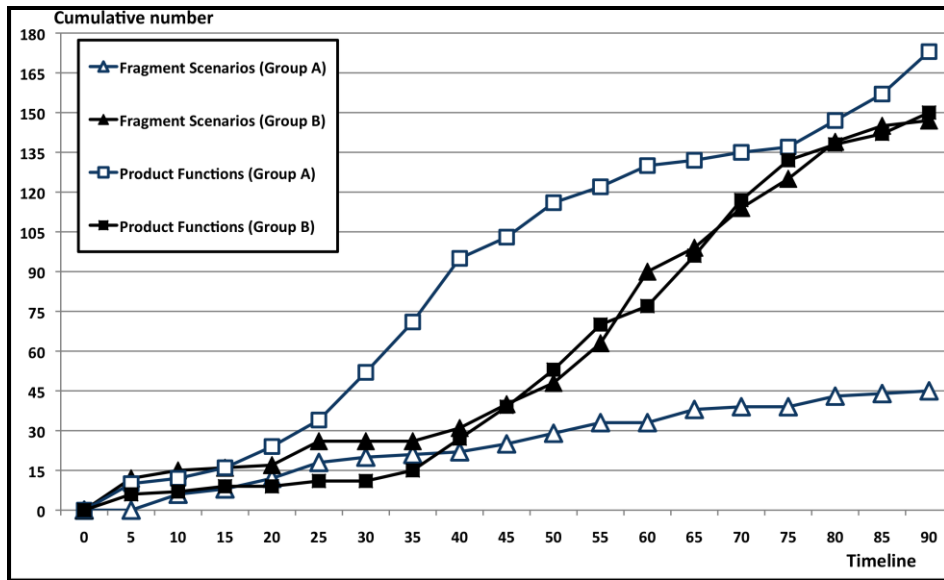


Figure 30: Comparison of group A & B's coding results

On the other hand, we also analysed the total time spent on the personas. In group A, they did not create any persona, while as in group B, they created seven personas and spent 26 minutes 33 seconds on building and using personas (% 30 of the total meeting). Figure 31 shows the percentage of time spent on personas in each phase of the meeting. As the figure points out, personas were present through all over the meeting, except the first phase.

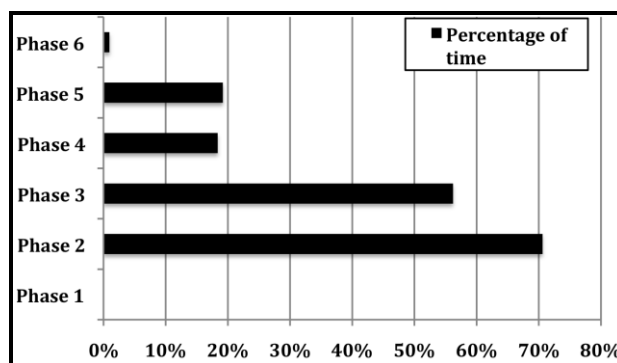


Figure 31: Percentage of time spent on personas in each phase of the meeting in group B

In conclusion, global and detailed analyses show that in contrast with group A, in group B the scenarios and personas are created and used during the meeting, which prove the reliability of the experiment data in Exp-2. However, as mentioned before reliability of the

gathered data was only tested in Exp-2. Thus, the same analysis has also to be carried on the video recordings of the other experiments, in order to ensure their validity.

In section 2, we explained how the reliability of the gathered data will be analysed.

5. Reliability of the Experiment Results

While realizing the data analysis, in some cases we base on the literature and use objective measures that their credibility is already approved in statistics, such as Spearman's rho. However, we also realized some measurements that the analysing process is less robust and subjective. In that case, we try to use more than one coder and check their level of agreement through inter-coder agreement coefficients. In the following, the Cohen's kappa calculations for the 5W tables' analysis are discussed.

Cohen's Kappa calculation of the 5W tables' analysis

In this study, for each experiment a double coding is realized. One of the coders is stable for each experiment, who is aware of the aim of the study and experienced on coding process. The other coders are blind about the aim of the study in order to eliminate the expectancy bias. Each coder is provided with the same coding schema and they realize coding process individually by respecting same coding process.

For example, suppose that the table below is the synthesis of the two coders' coding tables completed individually. The coder 1 mark with the letter "A", if he thinks that the subject gave an answer, which fits into that category, where as the coder 2 mark with "B". On the other hand, the coders are free to add a new category. For example, in the given example coder "A" adds the category A1-4 and thinks that SP1 and SP3 has given the answers, which fits into that category. Note that the new categories are compared to control, if there are common categories added by both of the coders.

Code	Subjects			
	SP1	SP2	SP3	SP3
A1-4	A		A	

Table 14 A part of double coding schema (5W table)

Because the numbers of coders is limited to two and the data is nominal, inter-coder agreement between coders is determined by using Cohen's Kappa. In this study, each coder has two options for each category listed in the coding schema: either the coder will decide that the subject give an answer, which fits into that category (labeled as positive) or not (labeled as negative). For example, if we continue with the same example, there are in total 3 common positive answers and 7 common negative answers. Additionally, coder 1 has 3 positive and 3 negative answers, which is reverse of coder 2's answers. Then, the Matrix table for the Kappa Calculation is then:

Matrix 2 Kappa index matrix for the given example

The total $p_{1(C1)} + p_{2(C1)} = p_{1(C2)} + p_{2(C2)} =$ (Number of the categories listed on the coding schema) x (Number of the subjects=4)

Kappa Index for this example is: 0,44. Once the inter-reliability of the coders is checked and the researchers are convinced about their reliability, the results of the coding process can be analysed.

In the following, the indicators that are used to answer research questions are presented.

6. Evaluating the Reliability of the Findings

Kappa indexes calculated for each double coding of 5W tables before (Step 3) and after (Step 5) collective sessions in Exp-1 and Exp-2. Before coding the 5W tables of each experiment group, we started with Exp-1 and Exp-2, as preliminary analysis. Hence, we could evaluate the robustness of the coding schema and also the coding process. As Table 15 shows, in Exp-1 the coding results of the two coders agree substantially according to Cohen's Kappa Calculations. However, in Exp-2 the coders have moderate agreement. These first results show that the coders of Exp-2 have to get together and clarify the reasons of their differences in the coding. Hence, the reason of their disagreement can be detected, to check whether the way of coding or the coding schema itself has to be reworked.



Table 15 Kappa indexes of the double coding Exp 1 and Exp 2

Once the coders have discussed together about their coding, they detected two main reasons, which could cause the disagreements:

- While one of the coders considered only the answers given to the related questions, the other coder accepted answers as a whole and decided which answer is given to which question. For example, if a subject discusses about who can use the product while answering to the question “what for the product is designed”, the first coder did not consider it as an answer to the question “Who?”. However, it was just the opposite for the second coder.
- The first coder realised the coding of the all groups results the same day in succession, but the second coder coded the 5W table completed in step 5 a few days after coding the other ones. This might explain the less agreement on this coding.

So, two new coders were asked to do the coding of the Exp-2’s 5W tables, after warning them about these possible obstacles. As we can see from Table 16 these two coders also agreed substantially, even if they got fewer agreements than the coders of Exp 1.

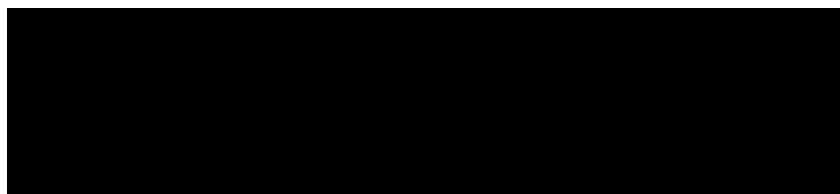


Table 16 Kappa indexes of the new coding Exp 1 and Exp 2

After discussing the replicability and the reliability of the experiment, the indicators that are used to answer the research questions are presented in the following. These indicators are discussed under the two main research questions: problem of understanding between design actors and problem of eliciting intended user needs.

7. Problem of understanding between design actors

In Chapter 2 section 4.4.1, it was suggested from the literature review that the shared understanding of the requirements could be defined from two different perspectives:

- **Convergence:** They get agreements and converge towards common perspectives in terms of requirements.
- **Perspective Clarification:** The subjects agree or disagree in terms of the requirements, and they are conscious about their agreements or disagreements. It is quite natural that there are conflicts within design group, but it is important that they are aware of them.

Hence, the research question of, whether scenarios and personas have an impact on the creation of shared understanding among design actors can be discussed under two sub-questions:

- Do they have an impact on the convergence?
- Do they have an impact on the perspective clarification?

Two different data will be used to focus on the shared understanding of the subjects: the 5W tables and ranking tables. The ways they are analysed and the rationale behind these analysing methods are described below.

7.1. Convergence

In order to test, whether scenarios and personas have an impact to converge subjects through a common perspective in terms of the requirements, we compared the level of convergence in each group. There are two main assumptions, which guide our analysis process:

Assumption 1: If they converge through common perspectives, the subjects' personal ranking lists should be coherent.

Assumption 2: If they converge through common perspectives, the subjects' 5W tables can converge through a common one after the collective meeting.

In the light of these assumptions, the impact of scenarios in terms of converging the subjects' perspectives through a common one is observed. In the following, the indicators used for the measurement and the rationale behind them, are explained.

7.1.1. Indicator 1: coherence of the ranking lists

As a reminder, in step 5 of the experiment (the after meeting measure), the subjects are asked to choose and rank the five most important functional requirements from the list that they have completed collectively during the design meeting. Ranking lists of the subjects are analysed to control, whether the subjects give the same importance to the listed functional requirements within the group.

Firstly, a general analysis is realized to verify the common points in their ranking lists. For example, even if they don't have the same ranking order, they might list the same functional requirements as the most important. That can be seen as an indicator that the subjects agree on the idea that these functional requirements are more important than the others. Thereafter, a statistical coefficient is used to measure the exact coherence of the ranking lists.

a. General analysis

We conduct a general analysis on the rankings of the subjects. The following points are observed as an indicator of the coherence of the ranking lists:

- the number of subjects who share the same list, even if the order may not be the same.
- the number of subjects who share the first three functions, even if the order may not be the same,
- the total number of functions which are listed by all of the subjects as important, even if the order is not the same,
- the number of functions listed by only one subject,
- the maximum number of subjects, who list the same function as the most important one,

In the following, the statistical measure, which is used to measure the exact coherence of the ranking orders is described.

b. Ranking order correlation coefficients

The aim of this analysis is to measure the extent to which the subjects agree, when ranking the 5 functions (that they consider most important) from the most important to the least important one. Thus, the statistical coefficients, which can be used to compare the correlation of the subjects' rankings, are searched out in the literature.

Howell (Howell 2009, pp. 303-311) proposes two correlation coefficients that can be used for ranked data: Spearman's rho and Kendall's tau. The author, after comparing with the Kendall's tau, underlines that Spearman's rho (with Pearson's ranked data calculation) remains the coefficient of choice. Similarly, Coolican (Coolican 1999, pp.445) also recommends using Spearman's rho (with Pearson's formula when there are tied ranks) to compare the correlation of the paired values. Hence, we decided to use Spearman's rho coefficient to compare the coherence of the ranking orders.

Spearman's rank correlation coefficient, also known as Spearman's rho (Spearman 1904), is the measure of statistical dependence between two ranked data. It is commonly used in biology in order to see, whether two measurement variables are correlated. For example, if one has measured the height and the weight of a group of people, Spearman's rho is then used to test, whether the two measurement variables change simultaneously. It is also commonly used in psychology in order to analyse the raters assigned scores for observed people, animals, objects, etc. For example, it is used to measure the agreement of two judges rating for a group of patient's aggressiveness. It is considered as a kind of reliability statistic for the measurement procedure.

Spearman's rho works by converting each variable to ranks. Thus, for the body weight example, the lightest person will get the first rank, second lightest the second rank, etc. In practice, there are simple procedures that are used to compute Spearman's rho ρ , for two sets of variables ranked separately. Even if these calculations are easy to carry out, Howell underlines that when there are ties (e.g. a judge gives the same order to the different variables), these formulas might lead to a wrong answer. That is why it is better to apply Pearson's formula to calculate Spearman's rho (Coolican 1999, pp. 445), as shown in the following.

$$\rho = \frac{N \sum XY - \sum X \sum Y}{\sqrt{(N \sum X^2 - (\sum X)^2) - (N \sum Y^2 - (\sum Y)^2)}}$$

Equation 2: Spearman's rho calculation (Coolican 1999, pp. 445)

In the formula, X and Y refer to the variables (in our case the order of each function attributed by two different subjects) and N refers to the sample size (in our case the total number of functions to be ordered).

In our case, Spearman's rho (ρ) is used to observe, whether the subjects agree to each other's view as far as the importance of the functional requirements are concerned. In other

words, whether their rankings are unanimous. As mentioned before, the subjects are asked to list the five most important functional requirements, between the ones they define collectively. We make the assumption that all the other functions are given the same importance level by the subjects (6th level). For example, if there is a total of seven functions, and subject 1 (S1) gives them the levels of importance listed in (see Table 17), the functional requirements F6 and F7 are considered as less important compared to the other ones. Thus, we attribute them the same importance level, the level 6. For calculating of the ρ , we assign the same ranking to each of the equal values, which is an average of their position in the ascending orders of the values ((6+7)/2 in this example).

Functions	F1	F2	F3	F4	F5	F6	F7

Table 17: Rank order of subject 1 (S1)

Since, there are tied ranks (F6 and F7), we use the Pearson's formula to calculate ρ . For the given example the value of Spearman's rho is 0,23 ($\rho = 0,23$).

Subjects	F1	F2	F3	F4	F5	F6	F7

Table 18: Rank orders of subject 1(S1) and subject 2 (S2)

In the case, there are more than two judges (which is our case as we have four subjects in each group). Howell (Howell 2009, pp. 309) indicates that Kendall's correlation of concordance (W) can be used. The author mentions that: "it can be viewed as a function of the average Spearman correlation computed on the rankings of all possible pairs of judges". However, because there is no intuitive meaning attached to W, it is recommended to convert it to the average Spearman's rho ($\bar{\rho}$) for interpretation (Howell 2009, pp. 310). In this research, we decided to compute the Spearman's rho for each pair of subjects (hence, we can also check the correlation between pairs) and take the average, instead of bothering with W and its conversion.

Once the Spearman's rho is calculated, two new questions arise to be answered: the probability that the correlation exists (*statistical significance*) and how strong the correlation is (*strength*).

Significance of the correlation:

Statistical significance test eliminates the possibility that the results arose by chance, allowing a rejection of the null hypothesis (H_0). In simple words, it answers to the question of how likely it is that two rankings would agree by coincidence. Thus, once the Spearman's rho calculated, we have to check the significance of the gathered value. In our cases the null hypothesis (H_0) is that there is no correlation between the rankings of the judges. We will use the two-tailed significance test to evaluate this hypothesis (see (Coolican 1999, pp. 446-448), to get more information about the two-tailed significance).

Significance levels show how likely a result is due to chance. If the probability is less than or equal to the significance level, then the null hypothesis is rejected and the outcome is said to be statistically significant. Commonly used typical values are 0.1, 0.05, and 0.01. These values correspond to the probability of observing such an extreme value by chance. In other words, they correspond to the values, for which one chooses to reject or accept the null hypothesis.

Table 1 in appendix 11 shows the critical values of the Spearman's rho at different levels of significance, for two-tailed significant test. For the purpose of setting standard level of rejection for this project, we will use a 0.05 level of statistical significance. Hence, if the computed value for the Spearman's rho equals or exceeds the value indicated in the table for the given level of α (0,05), then the probability of this result occurs at random is equal or less than α . So, we reject H_0 and assume the observed correlation between the rankings of the two judges statistically significant (at this specified level of $\alpha \leq 0.05$). This gives support to the research hypothesis.

In the previous example, it comes from the Table 1 in the appendix 2 that; calculated ρ must be equal or greater than the table value for the significance. For the given example, we gathered $\rho = 0,68$, however critical value for $\alpha \leq 0,05$ two-tailed significance with $N=7$ is 0,786; which means our value is smaller than the table value, hence the correlation between rankings is not statistically significant at this specific level of α .

Strength of the correlation:

The value of the Spearman's rank correlation coefficient varies from -1 to +1. The -1 indicates a perfect negative correlation, while the +1 indicates a perfect positive correlation. A correlation of 0 means there is no relationship between the two variables. By taking Landis and Koch's standards for interpreting Kappa Index (Landis et Koch 1977), the coefficient might be interpreted as defined in Table 19. The same table can be used also for interpreting negative correlations. For example if the $\rho = -0,25$, then it will be interpreted as a fair negative correlation.

Table 19: Interpretation of the Spearman's rho

According to the table, for the result ($\rho = 0,68$) gathered in the given example, there is a substantial positive correlation between the rankings of these subjects. However, the interpretation might change according to the context of the question.

Interpreting of the Findings:

While interpreting the findings, it is important to consider that:

- A correlation can be **strong** and yet **not** significant
- In the contrary, a correlation can be **weak** but **significant**
- The key factor is the **size of the sample**.

For small samples: it is easy to produce a strong correlation by chance, so that we have to pay attention to significance to deduce conclusions.

For large samples: it is easy to achieve significance, so that we have to pay attention to the strength of the correlation to determine.

For example, in the given example, even if substantial positive correlation obtained among subjects, the significance of the correlation is not attempt. Since, the sample size (N=7) is small, it is easy to produce a strong correlation by chance. For example, if the number of

functional requirements to be ranked were hundred instead of seven, it would be easy to achieve significance. However, it would be more difficult to get a strong correlation.

7.1.2. Indicator 2: convergence of the 5W tables

The main reason for analysing the individual 5W tables of the subjects is to gather a general idea on:

- Whether the subjects' individual representation of the product are evolved during the design meeting,
- Whether the subjects converge to a common representation of the product's requirements.

To answer these questions, we have to analyse not only the 5W table completed before the design meeting, but also the one completed after the meeting. Hence, we can observe if they already had common perspectives, or if they converged to a common one thanks to the design meeting. Then, the group results can be compared to measure the effectiveness of scenarios in terms of converging of the subjects to common perspectives.

So, a coding schema is constructed to analyse the 5W tables. The following indicators are calculated in order to compare the results of the 5W tables before and after the collective meeting for each group:

- The number of ideas produced before and after the collective session,
- The number of ideas shared by all the subjects before and after the collective session,
- The number of ideas shared by two or more subjects before and after the collective session,
- The number of ideas generated and dismissed. *Generated ideas* are the ideas, which are not mentioned by any of the subjects in the "before" step, but one or more subject in the "after" step. *Dismissed ideas* are the ideas, which are mentioned by one or more of the subjects in the before step, but none of them in the after step,
- The number of dismissed ideas shared by all subjects and the number of ideas shared by two or more people,

- The number of generated ideas shared by all subjects and the number of ideas shared by two or more people.

In the following, the detailed description of the coding schema and the coding process are presented.

a. Creation of a Coding Schema

Based on the corpus of our previous Crowds spirit study (Chapter 5 see 2.2.2) and on the preliminary analysis of the 5W tables, a coding schema is constructed. All the given answers to the 5W tables are listed and the similar ones are gathered under the same category. For each category a deterministic code is attributed and a description of the category is also given. This coding schema is also completed by the Crowds spirit corpus. The created coding schema is discussed and consolidated during the regular meetings realized by research project members. The preliminary version of this coding schema was tested on 5W tables, leading to some corrections and enhancements. This preliminary coding helped to define whether the coding schema was robust enough for being used by independent coders.

The final version of the coding schema is the list of the categories of all-possible answers to the questions in 5W table. Table 20 shows a sample of coding schema. For the question “Who?”, one of the possible answers is the “family members”. All the answers, which mean the family members, are categorized under this category “family members”, which is labelled by the code A1-1. The letter A signifies to which question the answer is given. A1 signifies that the answer is given to the first sub question of that question (e.g. for whom the product will be designed?). And finally, the A1-1 means that it is the first answer category of this sub-question. A description of this category is also given on coding schema. Because the coders are French, the coding schema is constructed in French (for the whole coding schema see appendix 12)

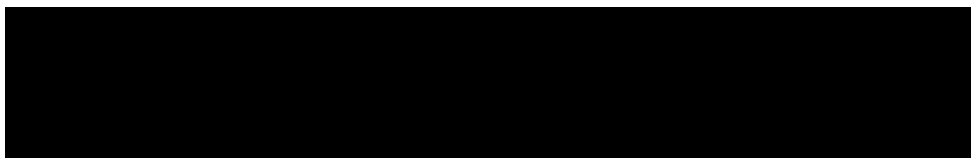


Table 20: Example of coding category (5W table)

b. Coding process

To allow the coding by different individuals, the steps to follow up are standardized:

1. Check each significant answer given to each question by a subject;

2. Find the related category of that answer in the coding schema;
3. Put a tick on the related category in order to indicate that the subject has given an answer to that question, which fits into that category.
4. Add a new category if the answer does not fit into any category

For example, if the subject SP1 gives the answer “family” for the sub-question “for whom the product will be designed?”, then the coder puts a tick to this category for SP1, on the coding table (see Table 21). The coders are also free to add a new category if they believe that the answer does not correspond to any existing category (see Table 21).

Code	Subjects			
	SP1	SP2	SP3	SP3

Table 21: Coding process (5W table)

The same process is followed for coding of the before and after 5W tables of all the subjects.

7.1.3. Indicator 3: convergence of the FCM tables

In order to evaluate if the subjects converged to a common FCM table collectively or there were the subjects who did not agree with the table, during the interview step the subjects were asked to comment on the FCM table. The subjects clarified, whether they agree with the functions listed on this common FCM table. Based on their answers, we compare whether they converge to a common FCM table.

7.1.4. Indicator 4: convergence during verbal communication

The above-mentioned quantitative analysis conducted on pre-test and post-test measures provide good insight about perspective clarification and convergence of the subjects in groups. In this section, we discuss our general impressions about scenarios and personas and their role in-group discussion. For this purpose, we observe verbal communication of the subjects and

control: if these methods create a common reference and if they help argumentation and decision making within group members.

7.2. Perspective Clarification

One of the questions asked to the subjects during the interview step is if in their point of view, in the ranking order table, which was completed individually, the order of importance of the functional requirements will be shared by the group (see appendix 10 to check all questions). Moreover, they are asked to give some more details about who in the group will give the same answers, and who will not, on which functions will be the differences (considering either the ranking or the weighting of these functions). Thus, by considering their interviews, we can check if they are aware of their agreements and disagreements on the ranking table.

8. Problem of understanding intended user needs

As mentioned in chapter 3, sections 5.3 and 6.3, in the literature many of the reasons for what the scenarios and personas are used in design process are discussed. In this section, we will realize a deeper analysis on some of these discussed characteristics.

8.1. The functional requirements elicitation

In each group we observe the number of functional requirements listed and discussed. Our underlying hypothesis is that the chance to generate good solutions; increases with the number of functions generated. In other words, our assumption is that, to be able to say that group B is more effective in terms of the requirement elicitation, the number of listed and discussed functional requirement have to be more elevated compared to group A.

8.1.1. Indicator 1: The number of listed functions in each experiment group

After a preliminary analysis of the FCM tables of the groups, we remarked that the concept of function and functional requirements weren't understood in the same way. In the chapter 2 section 4.5.1, we presented three concept of function discussed in the literature. We also explained that our understanding on function is the *desired effect of the product behavior*.

However, when we checked the function list of the subjects, we noticed that there were three concepts that the functions refer to. The first one fits into our understanding on the function. The second one is another listed function concept in section 4.5.1 "goals of the users".

Finally the last one that we label as “other”, they are the listed functions we are not sure about, in which category of concept we can insert.

- *Desired effect of the product behavior* (as they are asked to define as). For example, they listed “track conflicts”, “inform”, “display”, etc.
- *Goals of the user*. For example, some listed functions are the desired effect of the user actions “share data”, “consult planning”, “input data”, etc., that we categorize them under goals of the user concept.
- *Others*. We discuss the grammatical formalization of the functions as verb+object. However, the verbs “be” and “have” are confusing to insert them in one of the above mentioned categories. For example, some of the listed functions were “be easy to use”, “be ergonomic”, “have screensaver mode”, “be customizable”, etc. Being easy to use, ergonomic or customizable can be also related to structure of the product, not only its behavior. Similarly, having screensaver mode is more solution-oriented description than desired effect of product behavior. Because, here the subjects make the assumption that the product have a screen.

On the other hand, we also observed that the notions of criteria and metrics were not interpreted in the way that we described them. In some of the groups, the criteria refer to the functions. For example, in Exp 2 group A, one of the criteria listed for the function “inform” is another function “notify updates”. Thus, in order to compare the numbers of functions listed in each group, we analysed their FCM table as a whole, and we listed all “verb+object” (e.g. “prioritize events”) or “object+verb” (e.g. “event prioritizing”) phases. Thereafter, we compared for each group the number of listed functions that fits into these three categories.

8.1.2. Indicator 2: The number of discussed functions in each experiment group

The analysis explained in the previous section is carried out on the verbal communication of the subjects. All the coded sentences (section 3.2.1.c) in the form of “verb+object” and “object+verb” are listed and the repeated ones are eliminated. Then, the number of discussed functions that fits into above-mentioned three categories is compared between each experiment group.

8.2. Design Rational

There are two assumptions that guide our analysis of whether scenarios and personas help to capture design rationale:

Assumption 1: If scenarios and personas help to capture design rationale, there should not have much differences between the numbers of discussed and listed functions in Group B.

Assumption 2: If scenarios and personas help to capture design rationale, the captured scenarios and personas have to be informative about the decisions taken during the meeting (even for the people who were not present in the meeting).

Thus, first of we compared the listed and discussed functions in each group. We also verified if they are consciously eliminated or being forgotten. Thereafter, the content of the captured scenarios are analysed in order to check, if they are informative and give information about the way the functional requirements are decided within the group.

8.3. Creation of empathy within group

As discussed in chapter 3, section 5.2.1.a, in the literature four different ways that the actors of the scenarios are represented: in a limited way, by design actors, by personas, by already known characters and by real actors.

- **Unknown users:** Users might be represented in scenarios in a broader sense that they might be anybody, then in fragment scenarios the expressions like as you, people, children, etc., are used.
- **Designers as users:** The design actors accept themselves or people around them as the users of the product. For example: I, my sister, my daughter, my wife, etc.
- **Personas:** Users might be represented by Personas, and then in fragment scenarios their names are used. For example: Emily, Judy, etc.
- **Already known characters:** Already known characters like film actors or book characters might symbolize users. For example: Simpsons, Spiderman, Anna Karenina, etc.

Our assumption is that creation of personas will ensure in group B to keep the users alive and create empathy with them. Thus, in this group, the actors of the discussed fragment scenarios will be represented by personas. However, in group A the group members will have

tendency to see themselves or people around them as the users of the product, so that in fragment scenarios, they will prefer describing users by themselves or in a limited way. In other words, our assumption is that, to be able to say that scenarios and personas create empathy with users, the actors of the discussed fragment scenarios should be the personas in group B, while as the unknown users or the design actors themselves in group A.

Hence, once the fragment scenarios coded as described in section 3.2.1.c, we focus on the actors of them. In each group, we compared the number of actors of fragment scenarios that fits into each category.

8.4. General ambiance of the meeting

We evaluate the differences in general ambiances of the meetings. The awkward silences in each group are also compared. We describe an awkward silences as: a period of time, equal or more than five seconds, during which nobody talks (they might be crooning) or writes, and subjects glance round and at each other without knowing what to say. We determined the time being as equal or more than five seconds of silence, because we notices that after five seconds, the silence became disturbing within the group and subjects looked a little nervous.

8.5. Subjects' impressions about the methods

The interview questions between 12-14 (see appendix 10) are designated to collect information on, what the members of Group B think about the effectiveness of scenarios and personas to elicit and formalize intended user needs. Moreover, all of the subjects are asked to comment also on the 5W and FCM tables (interview questions 6 and 7), their strengths and shortcomings to formalize intended user needs, which can be complementary information about how we can support design actors for effective requirement elicitation and formalization. The answers of the subjects are transcribed by the researchers and summarized on a comparison table. This table not only shows the advantages and the disadvantages of the scenarios and personas that are mentioned by the subjects, but also the 5W and FCM tables' ones.

9. Concluding remarks

In this chapter, we discussed how the analysing activities are performed. Firstly, we discussed the way that the reliability of the experiment data is ensured. The reliability of the experiment data is evaluated through a two-step analysis. Global analysis helped researchers to familiarize with the data and have a global view on the structure of the meetings. Thereafter, a

detailed analysis is conducted on the verbal communication of the subjects, which is guided by the hypothesis that in the Group A and B the way they will discuss around the user needs should be different.

Finally, we focused on the indicators proposed to answer two main research questions. The, first research question, the impact of these methods on the shared understanding of the design actors, is treated under two sub questions: 1) their impact on the convergence of the design actors, which is dealt with the analysis of the 5W tables and the ranking tables, and 2) their impact on the perspective clarification, which is dealt with the analysis of ranking tables and subjects' interviews. While the analyses of pre-test and post-test data were quantitative, a qualitative analysis is also conducted on the verbal communication of the subjects. Similarly, some indicators are proposed to answer the second question, the impact of these methods on the understanding of the intended users' needs. This question is observed under three sub-questions: 1) their impact on the number of listed and discussed functional requirements, 2) their impact on the capture of the design rationale, and 3) their impact on the creation of empathy with in the group. The comments of the subjects about these methods, whether they are effective to elicit and formalize requirements, are also considered to answer that question.

Because of we are limited with time; we couldn't treat all the indicators for each experiment group. As discussed in section 4, because in Exp 2 we ensured the reliability of the gathered data, in this group we realised a complete analysis. Table 22 summarizes for each experiment group, if the related indicator is checked (labelled as "X") or not.

		Exp 1		Exp 2		Exp 3		Exp 4
		Group A	Group B	Group A	Group B	Group A	Group B	Group B
Convergence	Indicator 1	X	X	X	X	X	X	X
	Indicator 2	X	X	X	X			
	Indicator 3	X	X	X	X	X	X	X
	Indicator 4			X	X			
Perspective Clarification		X	X	X	X	X	X	X
Requirement Elicitation	Indicator 1	X	X	X	X	X	X	X
	Indicator 2			X	X			
Design rationale				X	X			
Creation of empaty				X	X			
Meeting Ambiance				X	X			
Subjects' impressions		X	X	X	X	X	X	X

Table 22: The indicators tested in different experiment groups

While in this chapter we only explained the analysing process, in the next chapter, the results of this process will be presented.

Chapter 7 Findings

In the previous chapter, analysing activities has been discussed in detail. The aim of this new chapter is to present and interpret the findings of the analysing process.

1. Introduction

The way that the gathered data are analysed has been explained in the previous chapter. In this chapter, we discuss the results of the analysing phase. As a reminder, in order to evaluate the impact of scenarios and personas on the problem of understanding between design actors is discussed under two sub-categories: 1) convergence of the perspectives, and 2) perspective clarification. On the other hand, the problem of understanding intended users' needs is observed under three sub-categories: 1) requirement elicitation, 2) capture of the design rationale, and 3) creation of the empathy for intended users. In the following, the gathered results are presented and interpreted.

2. The impact of the scenarios and personas on the convergence of the perspectives

In this section, we investigate whether the scenarios and personas have an impact on the convergence of the perspectives. There are four indicators that are used to deal with this question, which evaluate: whether subjects converge to a common ranking list, whether they converge to a common 5W table, whether they converge to a common FCM table, and whether these methods reinforce verbal communication.

2.1. Indicator 1: convergence of the ranking lists

If scenarios and personas make the subjects converge to a common perspective, then group B's ranking tables should be more coherent compared to group A's ones. This is the idea of this first indicator. In the following, we discuss the gathered results of our general and detailed analysis associated with this indicator.

2.1.1. General Analysis

Table 23 shows a comparison of the ranking tables of the subjects in each group (see appendix 17 for all the ranking tables). The first row on the table shows the total number of functions listed by the group. The second row shows the total number of functions that are listed in the top five of all subjects, even if the order is not necessarily the same. The third row shows how many functions are listed by only one of the subjects. The fourth row shows the number of subjects who list the same function in the first rank. The fifth row shows how many subjects share the first three functions, even if the ranking is not necessarily the same. Finally, the last row shows the number of subjects who share the same list, even if the order is not necessarily the same.

	Exp 1		Exp 2		Exp 3		Exp 4
	Group A	Group B	Group A	Group B	Group A	Group B	Group B
Total number of listed functions							
Total number of common functions listed by all subjects							
Total number of functions listed by only one subject							
Number of subjects listed the same function in the first rank							
Number of subjects who have the same first three (with/without same order)							
Number of subjects who have a common list (with/without same order)							

Table 23: The comparison of the ranking tables of the subjects

Table 23 shows that there is no group in which all the subjects listed the same function in the first rank. Similarly, in none of the groups all the subjects have the common first three functions. The results highlight that the groups have had the difficulty to converge to a common picture of the product. The best results are obtained in Exp 4, which is conducted with the industrial partners. This might be caused by the fact that the expert and novice designers do not have the same characteristics. Because the expert designers used to participate to similar meetings, they might more easily converge to a common perspective.

Based on a deeper analysis of the table, we can deduce the following findings for each experiment:

- **Exp 1:** in group A there are two functional requirements listed by all subjects, while as in group B there is one more. Moreover, in group A there is no common lists between subjects, while in group B two subjects have a common list and two subjects have the same first three,

even if the order is not the same. We can conclude that in this experiment the subjects of group B converged to a more common list compared to group A.

- **Exp 2:** in group A there is no functional requirement listed by all the subjects, while there are two for group B. Furthermore, in group A there is no common list between subjects, while in group B two subjects have a common list. Similarly with Exp 1, in this experiment the subjects of group B converged to a more common list compared to group A.

- **Exp 3:** in group A there are three functional requirements listed by all subjects, while there are two for group B. In group A, there are also three subjects who have the same first three functions, despite differences in their ranking. Apart from that, in group A there are two subjects, who have the same ranking list, while as in group B there is no subject, who has a common list with other subjects. In this experiment, in contrast with other experiments group A converged to a more common list compared to group B.

- **Exp 4:** in this experiment there is only group B. In this group there are three subjects who have a common list and they also share four functions with the subject left. We can conclude that, the subjects converged to a common list.

To sum up, while in Exp 1 and Exp 2 subjects of group B have more common ranking tables compared to group A. Moreover, in Exp 4, the results show that the subjects had similar ranking lists. However, in Exp 3 we have contradictory results with other experiments. Moreover, we cannot explain how group A in this experiment had almost as good results as the group B's of the other experiments. Thus, we cannot deduce the conclusion that scenarios and personas have a significant impact on the convergence of the perspectives. We have to look at the results of the detailed analysis to see, whether we have more exact results.

2.1.2. Detailed analysis

Before discussing the findings, we evaluated the significance of the gathered results, We noticed that only in Exp 1 group A and in Exp 3 group A's results are statistically significant at this significance level. We also noticed in some groups, even if the group average result is not statistically significant, some of the subject pairs' results are statistically significant. For example, although the average result of Exp 2 group A is not statistically significant, it is the case for the subject pair 3 and 4's result in this group. However, because we had small number of samples, we have already known that we have to pay attention to the significance in order to deduce conclusions. That is why, during the interview step the subjects are asked to comment on the rationale behind their rankings. All of the subjects were conscious about their

rankings and they had reasoning behind. Hence, we ensured qualitatively that the subjects did not ordered functions randomly, and the coherence did not gathered by chance.

As explained in the previous chapter (see section 7.1.1), in the detailed analysis we calculate the Spearman's rho (ρ) for each pair of the subjects. Table 24 shows the gathered results for each experiment group. The average of the paired subjects' results are also calculated, and presented in the table. In order to interpret the strength of the correlation we use Table 19 from section 7.1.1. Last row on the table shows the strength of the correlations.

When we check out the strength of the correlation of the groups on the table, we can notice that between seven design groups only two of them have substantial positive correlation and any of them has almost perfect positive correlation. These results underline the fact that there is a great problem of convergence in design groups. After a design meeting that took one and half hours, the subjects couldn't get agreement on the fundamental functional requirements of the product.

	Exp 1		Exp 2		Exp 3		Exp 4
	Group A	Group B	Group A	Group B	Group A	Group B	Group B
Subjects 1-2							
Subjects 1-3							
Subjects 1-4							
Subjects 2-3							
Subjects 2-4							
Subjects 3-4							
Average	<i>0,54</i>	<i>0,48</i>	<i>0,08</i>	<i>0,53</i>	<i>0,76</i>	<i>0,28</i>	<i>0,72</i>
Strength of the correlation	Moderate (+) correlation	Moderate (+) correlation	Slight (+) correlation	Moderate (+) correlation	Substantial (+) correlation	Fair (+) correlation	Substantial (+) correlation

Table 24: Spearman's rho calculated for each subject pair

The findings of the analysis also show that, in Exp 2, the subjects of group B have more common list compared to group A. Moreover, in Exp 4, the subjects of group B have substantial positive correlation. These findings can be interpreted as scenarios and personas have a positive impact on the convergence of the subjects to a common perspective. However, we have not the similar results in Exp 1 and Exp 3. While, in Exp 1 the subjects have similar correlations, in Exp 3 the subjects of group A have higher correlation than the subjects of group B. The group A in Exp 3 also have almost twice-higher correlation than the subjects of group B¹³ (in Exp 2),

¹³ This is the group for which we demonstrated an intensive use of scenarios and personas (see Chapter 6 section 4).

even if they did not use scenarios and personas. These findings show that in this group there were other better impacts rather than utilization of these methods, which converged the subjects to a common perspective. Thus, we cannot say that scenarios and personas have significant impact to converge design actors to a common perspective.

In conclusion, results of global and detailed analyses of this indicator do not allow us to conclude definitely that scenarios and personas have a major impact on the convergence of the perspectives.

2.2. Indicator 2: convergence of the 5W tables

Another assumption discussed in the previous chapter section 7.1.2 is that in group B the subjects' 5W tables have to be more coherent compared to group A's ones, in order to conclude that scenarios and personas have an impact on the convergence of the subjects' perspectives on the product. The 5W tables completed before and after the design meeting are analysed as presented in section 7.1.2. Below, we discuss the new gathered results.

Table 25 and Table 26 point out the results of the analyses respectively in Exp 1 and Exp 2. The first row on the table shows the findings gathered from analysis of the 5W tables completed before the design meeting, while the second row refers to the 5W tables completed after the design meeting. The third row gives the information about the dismissed ideas during the meeting, and finally the last row about the new generated ones.

- **Exp 1:** The table shows that in group A (the left side of the cells), before the collective activity, a total of 44 ideas are listed on the 5W table and only 7% of them are shared by all the subjects and 34% are shared by two or more subjects. However, after the collective activity there are in total 43 ideas listed. 7% of them are shared by all subjects and 42% of them are shared by two or more people. The results show that, after the collective meeting, while the percentage of ideas shared by all the subjects remains constant, the percentage of ideas shared by two or more subjects increases in this group.

In group B, before the collective activity a total of 27 ideas were listed on the 5W table and only 7% of them are shared by all the subjects and 37% are shared by two or more subjects. After the collective activity, 24 ideas are recorded and 13% of them are shared by all the subjects and 38% of them are shared by two or more subjects. In this group, while the percentage of the ideas shared by all the subjects increases, the percentage of ideas shared by two or more subjects remains stable.

If we base our interpretation on the percentage of the ideas were shared by the participants, then we can conclude that group B converge to a more common perspective compared to group A. On the other hand, if we base our interpretation on the percentage of ideas shared by two or more subjects, then we can conclude quite the opposite.

Furthermore, when we check the dismissed ideas in each group, we can observe that while in group B 18% of the ideas are shared by two or more people, in group A almost 0% (0,1%) of them are shared by two or more subjects. That means, in group A these ideas were mentioned by one of the subjects and they were eliminated during the meeting. At this level of analysis, we cannot say whether the subjects eliminated these ideas consciously, but we can say that many ideas were dismissed in both of the groups (16 in group A and 11 in group B). To go further in this question the interactions during the meeting should be analysed. Finally, the percentage of shared new generated ideas is the same for both of the groups. Even if there are many new ideas generated after the meeting in both of the groups, they are not shared by all the group members and lowly shared by two or more of the subjects. This can be interpreted as the subjects found these ideas just after the meeting by themselves or the subjects listed the ideas refused by the other subjects during the meeting. In both of the conditions, the generated ideas were not the ideas created collectively during the meeting.

	Total number of ideas	Number of ideas shared by all subjects	% of ideas shared by all subjects	Number of ideas shared by 2 or more subjects	% of ideas shared by 2 or more subjects
Pretest 5W table					
Posttest 5W table					
Dismissed Ideas					
Generated Ideas					

Table 25: Coding results of 5W tables (Exp 1)

- **Exp 2:** Table 26 shows that in this experiment, while in group A before the collective activity a total of 56 ideas were listed on the 5W table, only 7 % of them are shared by all the subjects and 30 % are shared by 2 or more subjects. After the collective activity, 37 ideas are recorded, 8 % of them are shared by the all subjects and 38 % of them are shared by two or more subjects. In this group, while the percentage of ideas shared by all subjects remains constant, the percentage of ideas shared by two or more subjects increases.

In group B before the collective activity a total of 48 ideas were listed in the 5W table, and 17 % of them being shared by all the subjects and 52 % being shared by 2 or more subjects.

After the collective activity, 33 ideas are recorded, 27 % of them are shared by the all subjects and 39 % of them are shared by two or more subjects. In this group, while the percentage of ideas shared by all subjects increases, the percentage of ideas shared by two or more subjects decreases.

Similarly with the Exp 1, if we base our interpretation on the percentage of the ideas were shared by all subjects, we can conclude that group B converge to a more common perspective compared to group A. On the other hand, if we base our interpretation on the percentage of the ideas shared by two or more subjects, then we can conclude quite opposite.

Moreover, the table shows that there are many ideas generated and dismissed in both of the groups. Similarly with the results gathered in Exp 1, the generated ideas were not the results of conscious group decisions.

	Total number of ideas	Number of ideas shared by all subjects	% of ideas shared by all subjects	Number of ideas shared by 2 or more subjects	% of ideas shared by 2 or more subjects
Pretest 5W table					
Posttest 5W table					
Dismissed Ideas					
Generated Ideas					

Table 26: The coding results of 5W tables (Exp 2)

In both groups, if we base our interpretation on whether the ideas were shared by all of the subjects, we can deduce that subjects of group B converged to a more common list compared to group A. However, there is no distinctive difference between the results of the groups, to conclude that scenarios and personas have a significant positive impact on the convergence of the perspectives. For example, in Exp 1, while the percentage increases from 7% to 13 % in group B, in group A the percentage remains constant at 7%. It is also important to note that small changes on the numbers cause big changes in percentage, because the numbers are not very high. In the given example, only one more function shared by all of the subjects after the design meeting, caused a 6 point increase in group B's shared percentage.

2.3. Indicator 3: convergence of the FCM tables

In order to evaluate if the subjects converged to a common FCM table collectively or there were the subjects who did not agree with the table, during the interview step the subjects were asked to comment on the FCM table. The subjects clarified, whether they have agree with

the functions listed on this common FCM table. Table 27 summarizes the comments of the subjects about the listed functions. The table shows that in each experiment group, all of the subjects mention that they globally agree with the listed functions.

It is important to open a parenthesis here. The table also points out that some of the subjects mentioned that although they globally agreed with the listed functions, they did not agree with some specific functions. In other words, the subjects accepted to list some functions on the FCM table that they did not agree with. The subject might have accepted these functions because of many different reasons, such as the majority of the group might have supported them, or the manager of the meeting might have forced subjects to list them, etc. That means the subjects have converged to common representations of the product without changing their own perspectives. These results arises new scopes about our notion of convergence.

If we go back to our research question, from the table we cannot conclude that the groups who use scenarios and personas have a better agreement on the listed functions than the other ones.

		Subject 1	Subject 2	Subject 3	Subject 4
Exp 1	Group A				
	Group B				
Exp 2	Group A				
	Group B				
Exp 3	Group A				
	Group B				
Exp 4	Group B				

Table 27: The comments of the subjects on FCM table

2.4. Indicator 4: convergence during verbal communication

Contrary to the previous findings, our qualitative analysis on the video recordings of each group in Exp 2 shows that personas have a positive impact on the perspective clarification and convergence in discussion. In the following, we discuss our observations.

In **Group B** personas created a common reference that each subject was aware of about whom they were talking, without giving so much detail. When they were talking about a persona, they were more or less conscious about the personas and their characteristics. For example, when subject 3 mentioned that persona Judy’s daughter might need help to use the

product (in 55th minute without even saying the name of the persona); they all knew that he was talking about the persona Emily, and she might need help because she is six years old.

“Subject 3: [...] because when her daughter's using it, she will be there to support her child as well.”

Moreover, the subjects used personas as a medium to communicate their viewpoints. In other words, they made reference to personas, while presenting their arguments. For example, to support his point of view that the product has to be portable, in the 40th minute of the meeting, subject 1 referred to the persona Emily and created a fragment scenario around her:

“I think one of the criteria is portable, isn't it? So, she can take it into garden and play with her teddy.”

They also evaluated requirements and make decisions by referencing to the Personas. For example, subject 1 (in the 12th minute of the meeting) eliminated the requirement “reminding the bills” by referencing to the persona Clayton.

“I think one of the usefulness of the calendar is to see when the bills are due and stuff like that. [...] But he is not going to be using those sorts of things.”

Moreover, utilization of the personas helped design actors to identify conflicting requirements. In other words, they realised that a requirement, which can be essential for a persona might be disturbing for another one. For example, while discussing about “sharing the personal planning with the other users of the calendar”, they discussed that everybody wouldn't want to share their planning with other people. Another example, while the mother Judy would want to see his son Clayton's calendar, Clayton would not agree with that. Thus, this requirement was eliminated through a common agreement within the group.

“Subject 1: The thing is if we do that what is his name? Clayton? Whatever.”

Subject 3: Clayton

Subject 1: Clayton, yes. He wouldn't use it then. If he knows that mother can see everything.”

In total nine proposed requirements were eliminated in similar ways, because they were not appropriated to one or more personas. In other words, the subjects clarified and also strengthened their arguments based on the personas' characteristics and on the scenarios created around them. Due to the fact that all the subjects built personas collectively, this created common references and negotiation process was easier to take decisions.

In *Group A*, we did not notice such constructions. The subjects did not discuss about, who are the real users of the product. Moreover, there is no elimination of the requirements. The group just focused on listing the functional requirements.

2.5. Discussion

The first two indicators discussed above, gathered through pre-test and post-test analysis, give good insights about the convergence of the subjects in design groups. The findings show that the groups, which used these methods, did not have a significantly better common vision of the product, compared to the other groups. Thus, we cannot conclude from these quantitative analyses that scenarios and personas have a significant impact on the convergence of the perspectives.

However, the qualitative analysis of the verbal communication of the subjects in group B (Exp 2) shows that, personas were used in this group as an argumentation tool. In other words, the subjects justified their ideas by creating a scenario around personas, such as “my idea is good because the persona can benefit from it in this way”. The decision-making was also guided by the personas. They eliminated the requirements that they judged non suitable for the personas.

In conclusion, even if these methods during the meeting can be a good medium to argument and negotiate the individual ideas, they do not help the groups to get better results in terms of having a common perspective on the product, compared to other groups. In other words, without their presence the groups get similar, in some case even better results. Thus, we cannot demonstrate in this research study that these methods have a significant impact on the convergence of the perspectives.

3. The impact of scenarios and the personas on the perspective clarification

One of the questions asked to the subjects during the interview step was that if in their point of view in the priority table, which was completed individually, the order of importance of the functions would be shared by the group. In the case that their answer was negative, they were asked to comment on the differences that could be determined. Table 28 shows the summary of the given answers of the subjects in each group.

As we can see from the table, the subjects, who indicate that the list will be shared, either believe that the list will be shared as a whole or partially:

- Yes, it will be shared;
- Even if the order is not the same, the list will be shared;
- The first three functions will be shared, even if the whole list is not the same;
- The first function will be shared;
- It will be common with some of the subjects but not with the others.

		Subject 1	Subject 2	Subject 3	Subject 4
Exp 1	Group A				
	Group B				
Exp 2	Group A				
	Group B				
Exp 3	Group A				
	Group B				
Exp 4	Group B				

Table 28: The comments of the subjects about the ranking order of the functions

Hence, by considering their answers we compared the way that the ranking of the functions is shared in each experiment group and if it corresponds to the answers of the subjects. In the following, we will discuss about the findings of each experiment group.

- **Exp 1:** In **Group A**, as we can see from Table 28, two subjects think that the first three functions would be shared within group, but we notice that it is not the case. Another subject assumes that the first function would be the same for everyone, but Table 23 shows that only two subjects have the same first function. Subject 3 also believes that the list would be the same even if the orders were not the same. However, we notice that they have all different lists of functions. On the other hand, subject 4 thinks that subject 2 would give more importance to function F4, but we notice that while he ordered it in second place, subject 2 ordered it in the fourth rank (see appendix 17). Similarly in contrast with what subject 4 thought, subject 2 did not list the function F13 on his list. In **Group B**, the subjects commonly agree that the lists would be

the same, even if the orders are not the same. As the Table 23 demonstrates, there are three functions that are common for each subject and two subjects share the same list, but not all the subjects. On the other hand, subject 2 assumes that he would have the same ranking with subject 3, but not with subject 1. When we look at Table 24, we can notice that, an almost perfect correlation with subject 3, while as fair positive correlation with subject 1. So, he was perfectly aware of their agreements and disagreements. We can conclude that, in group B the subjects were more aware of their agreements and disagreements.

- **Exp 2:** In *Group A*, two subjects think that the group's ranking tables would be different, which is quite true because none of the functions that was listed by the whole group (see Table 23). Subject 3 refused to give an exact answer. Only subject 4 estimates that the group's ranking would be similar, except the subject 3's one. In contrast with his assumption, according to Table 24, subject 4 has a substantial positive correlation with subject 3. In *Group B*, they commonly imagined that the lists would be common, at least the first three. If we look at the Table 23, we can notice that, two subjects who have a common list, but not ordered in the same way. In the same manner, two subjects have the same first three functions in their list. Moreover, two subjects indicate that the functions F4, F6 and F1 are the fundamental ones and would be listed by everyone, which was true for functions F1 and F6, but not for F4. The last one being even so common for three of the subjects. On the other hand, subject 1 believes that his ranking order would be different from other group members' one. He is partially wrong in the sense that he has an almost perfect agreement with subjects 2 (with the correlation coefficient=0,98). In both experiment groups, the subjects were similarly aware of their disagreements and agreements.

- **Exp 3:** In *Group A*, they commonly agree that the first three functions would be the same, only subject 3 thinks that they would have different lists. Table 23 demonstrates that aside from subject 3, the subjects have the same first three, which shows that in this group, the majority of the subjects are aware of their agreements. In *Group B*, they commonly agree that the list wouldn't be shared, however some subjects assume that there are the fundamental functions that should be shared: F1, F5 and F7. They are right about the functions F1 and F5, but not for F7, which was listed as important by only two of the subjects. In this experiment, both groups seem to be similarly aware of their agreements and disagreements.

- **Exp 4:** In *Group B*, because of some technical problems, we got the recordings of only two interviews. One of the subjects claims that more or less they would have the same list and the other one assumes that the first three functions should be likewise. Even if the first

three are not the same in this group, three subjects who have the same list (without the same order) and the last subject have four common functions with the others. We can conclude that their assumptions about the ranking lists are relevant.

We can conclude in Exp-1, the subjects of group B were more aware of their agreements and disagreements in terms of the importance given to the functional requirements. Similarly, in Exp 4 they were commonly conscious about their agreements. However, in Exp-2 and Exp-3 the subjects of group A and B were similarly conscious about the differences in their perspectives. Thus, we cannot deduce the conclusion that the scenarios have a significant impact on the perspective clarification.

4. The impact of scenarios and personas on the requirement elicitation

There are two indicators that are used to evaluate the performance of the subjects: 1) whether they are more effective in terms of the number of listed functions, and 2) whether they are more effective in terms of the number of discussed functions. The underlying assumption was that the chance to generate a more complete product definition; increases with the number of functions generated in the early stage.

4.1. Indicator 1: impact on the number of listed functions

In each experiment group, we determined the number of listed requirements formalised in three different function concepts (as discussed in chapter 6, section 3.2). As we can see from the Table 29, in Exp-1, group A was more effective in terms of the number of functions listed in the FCM table. In contrast with Exp-1, in Exp-2 the group B was more effective. In Exp-3, the groups have similar results. The results show that the groups, which use scenarios and personas, are not more efficient compared to other groups.

	Exp-1		Exp-2		Exp-3		Exp-4
	Group A	Group B	Group A	Group B	Group A	Group B	Group B
No of desired effects of the product behaviour							
No of user goals							
No of others							
Total No							

Table 29: The number of different function concepts listed in each experiment group

4.2. Indicator 2: impact on the richness of the discussed functions

In Exp 2, we determined for each group the number of discussed and listed functions of the three different types. Table 30 points out that in group B, the functions are discussed mostly in the form of user goals, while as in group A in the form of the desired effects of product behaviour. Moreover, differently from group B, in group A there are more listed and discussed functions that fit into the category ‘others’. The table also shows that group B is more effective in terms of the total number of discussed functions compared with group A. We can infer that the scenarios and personas enhance the richness of the discussions. However, at the end of the meeting, the groups listed similar numbers of functions in their FCM table, even if group B have a bit higher number of listed functions.

	Exp-2	
	Group A	Group B
No of listed desired effects of the product behaviour		
No of discussed desired effects of the product behaviour		
No of listed user goals		
No of discussed user goals		
No of listed others		
No of discussed others		
Total (Listed)		
Total (Discussed)		

Table 30: Number of listed and discussed functions in the three concept categories (Exp-2)

In conclusion, the findings demonstrate that the group that use scenarios and personas has a better performance, in terms of the number of different requirements discussed during the meeting. However, the groups have similar performances in terms of the listed requirements. Hence, we can conclude that while scenarios and personas enrich the discussions during the meeting. However, we cannot deduce the conclusion that they have a positive impact on the overall requirement elicitation activity.

5. Impact on the capture of design rationale

In Exp 2, discussing around the characteristics of personas helped group B to create usage scenarios, which allowed them to elicit functional requirements. For example, the discussion, which occurred in the 52nd minute of the meeting, shows how they elicited the requirement “manage conflicts” through one of the characteristic of persona Judy; which is having busy social and work life.

“Subject 2: So, Judy teacher. So again, she is goanna one or like separate her you know work live and social live.

Subject 1: work life and social life

Subject 2: So, she is a teacher like got a busy social life likes gardening. So, she wants

Subject 3: She wants to see multiple schedules.

Subject 2: Yes, so, conflict management”

After the discussion above, the group listed “manage conflict” on the FCM table, as a function. However, two main goals of the user guided the groups to list this function: “separate work life and social life” and “see multiple schedules” were not captured. Furthermore, some discussed user needs are eliminated during the discussions. The reasons for what they were eliminated were neither captured. In other words, the group did not keep the trace of the rationale behind their decisions.

The capture of scenarios is discussed in the literature as a way to capture design rationale (see Chapter 3 section 2.3.1). Similarly, the example given above also shows that the scenarios can be used to explain the reasons behind the listed functions. However, during the meeting, even if many similar scenarios were created and discussed, none of them was captured. Some sketches were used as a media to represent scenarios, but there was no other written trace of the scenarios. Although, sketching helped the group to understand the scenario context, it wasn't enough to capture the scenarios as a whole. For example, to a person who was not in the meeting, the sketch of the scenario represented in Figure 32 will not signify anything. During the meeting, one of the subjects suggested to write down the scenarios (subject 1 in 21st minute of the meeting: *“Yeah. Shall we start writing these things down? I think we're going to forget.”*), but they did not perform it. However, they captured all the personas (in total seven personas), their characteristics and a photo of them (see Figure 32). Similarly, in other experiment groups, while created personas were captured, none of the discussed scenarios was documented.

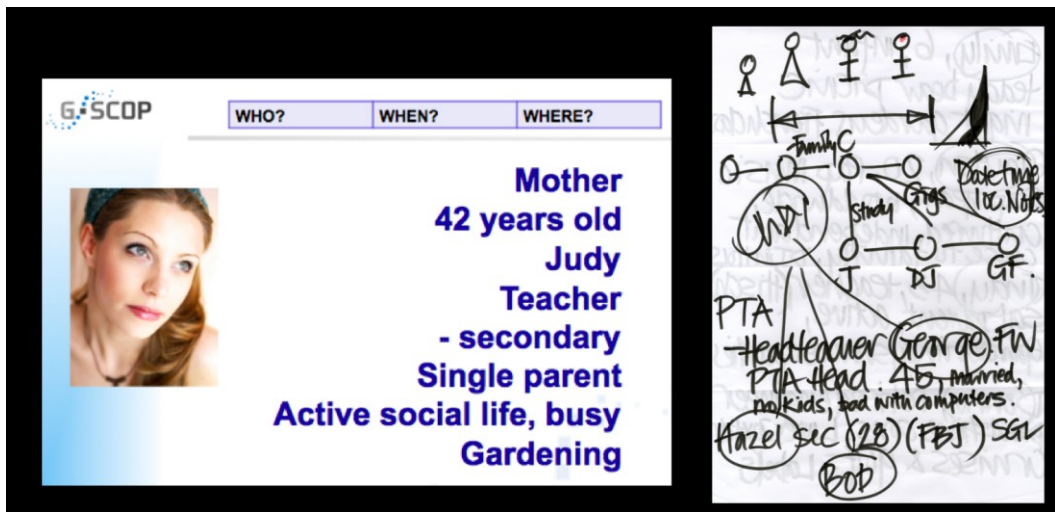


Figure 32 Respectively persona Judy and sketch of a scenario created in group B (Exp 2)

In Exp-2, in group A also many functions were discussed, either they were grouped together under a broader category or they were dismissed unconsciously. In this group we did not observe the elimination of the functions after a negotiation process. However, in group B there were nine functions eliminated consciously. This is related to one of the discussed profits of the persona usage (see section 2.4); they highlight the functions, which might be conflicting for different personas.

As mentioned before, Table 30 also shows the number of discussed and listed functions that fit into different function concept categories. We can notice that the discussions during the meetings in both of the groups were richer than what was captured at the end.

The findings show that as discussed in the literature, the scenarios show promise for keeping the trace of design rationale. However, design actors have no tendency to capture them for revealing the discussed assumptions and decision-making criteria. The design actors could be trained about the usefulness of capturing scenarios, and this process also could be supported with interactive tools.

6. Impact on the creation of the empathy

In group A of Exp-2, the idea to have a deeper discussion on who will use the product and have a common vision of the users was eliminated since the early stages of the meeting (between the 1st and 2nd minute). The manager of the meeting claimed that discussing around the question of “who?” wouldn’t be necessary to list the functional requirements of the product.

“Subject 1: Well, shall we go through the “who?”, whatever, so we all know that we're working on the same basis?”

Subject 4: No, let's just start listing some functions. [Okay]. Sorry mate, I don't think "who?" is going to be needed.”

In this group, although they didn't create any persona, they created some scenarios either around unknown people, themselves or general user groups like children, older people etc. For example, you can see below one of the scenarios created around the subjects in the 19th minute of the meeting:

“Subject 3: Invitation. Do you need all of them for planning a meeting? You know, suppose you want to execute one request, right? I want to have a meeting. And you say that: I need these people in a meeting. So, that agent on that morning will go to their calendars and will see what is the best time for the whole group. Do you need that agent?”

Subject 2: So, that is done automatically.

Subject 3: Yes. So, automatic intelligent agent.”

The scenarios were discussed just in short time periods and they didn't come back on a created scenario during the meeting.

As discussed in Chapter 6 section 4, group A (Exp 2) created a total of 45 scenario fragments, while as in group B the total number was 147. When we observe the actors of the built scenario fragments, we noticed that they are represented in scenarios in three ways; unknown users, the designers themselves and of course personas.

Figure 33 and Figure 34 show the gathered results, respectively from group A and B. The x-axis of the histograms shows the timeline of the meeting, while as the y-axis represents the cumulative number of created scenario fragments. In Group A, the subjects preferred to reference themselves or unknown people on fragment scenarios. There are 25 fragments scenarios, which were created around unknown users, and 20 around the designers themselves (Figure 33).

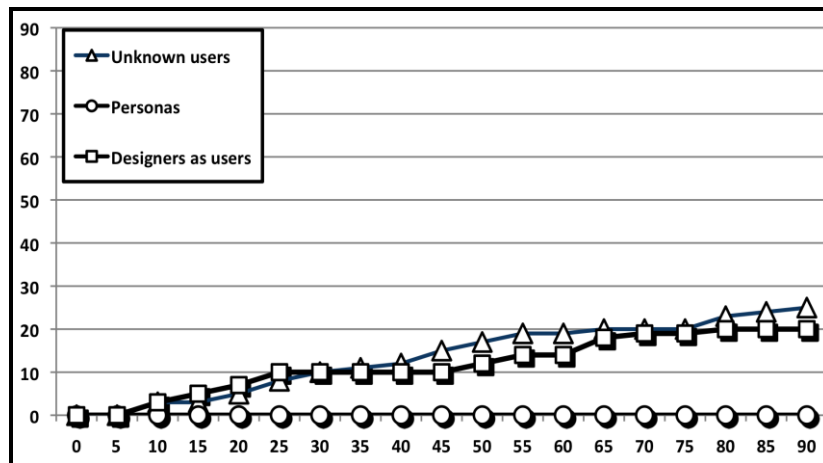


Figure 33: Analysing results of scenario actors in group A

In contrary, in group B, they built 80 scenario fragments around unknown users, 65 around personas and only 2 around themselves (Figure 34).

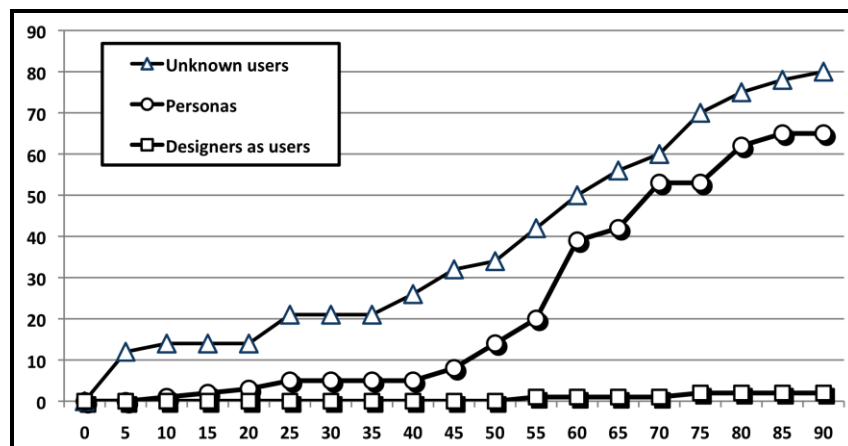


Figure 34: Analysing results of scenario actors in group B

The results show that, personas have a power to change the way that design actors think. Instead of talking about what they want, or how they might use the product, they recognize and understand the users' needs and work situations.

7. Impact on the ambiance of the meeting

When we analyse the video recordings of the experiment groups in Exp 2, we perceive that there are differences in terms of the ambiance of the meeting. In group B, the scenarios and personas provided the subjects to be more relaxed and confident. As one of the subjects mentions in the interview step, "scenarios played the role of icebreaker within the group". Several scenarios were created around personas. Because personas are imaginary people, the

subjects felt free to criticize them or make jokes about, which made the meeting enjoyable. The communication was intensive and more or less all the subjects participated.

However, in group A, they had difficulties to keep the conversation going long time. We observed that there are many awkward silences¹⁴ in this group. As we can see from Figure 35, in group A there are seventeen awkward silences, whose duration changes between five seconds to thirty-seven seconds. In the histograms (see Figure 35), x-axis shows the duration of the awkward silences in seconds and y-axis the starting time. Unlike group A, in group B there were only three awkward silences, with a maximum duration of nine seconds. Another interesting point is that while in group A the silences are more frequent towards the end of the meeting, in group B they become less frequent.

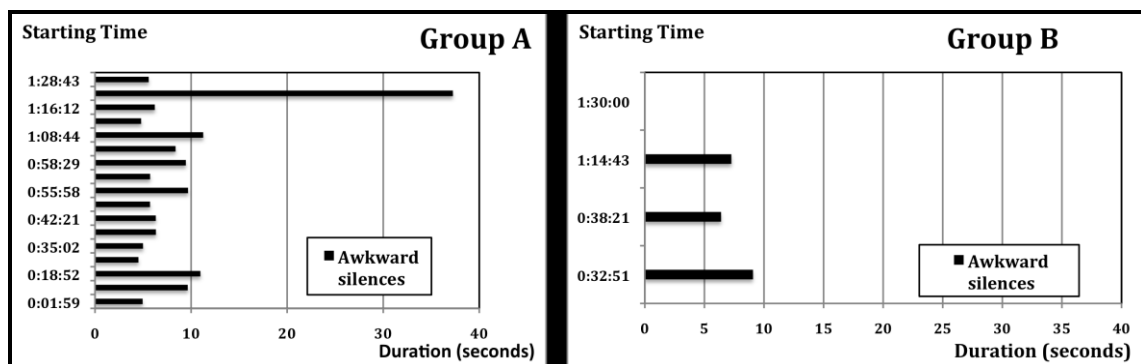


Figure 35: Awkward silences in design meetings respectively in group A&B

We can draw the conclusion that these methods are efficient to help design actors to feel relax and confident for sharing their ideas, participating to the discussions and make the meeting more dynamic.

8. Subjects' impressions about these methods

During the interview step the subjects were asked to comment on the usefulness of scenarios and personas to elicit and formalise the user needs. The following table (Table 31)¹⁵ discusses the answers of the subjects. The comments of the subjects on the 5W table and FCM tables are also summarized on the table.

¹⁴ See the definition of awkward silences in (Chapter 6, section 7).

¹⁵ It is important to note that, they combine the comments expressed several times. However, there might also be the comments against the listed ideas below.

	Positive points	Negative points
5W table		
FCM table		
Scenarios		
Personas		

Table 31: Feedback of the subjects on the different methods and tools they used

- **5W table:** This method was commonly regarded as a method that can be used in the early stages of the design process for the initial brainstorming, to familiarise with and assimilate the product idea. It was described as a method that one could put their initial ideas to not forget them. However, one of the subjects refused this common idea and claimed that this method was not appropriate for the early stages, but it could be used after a certain degree of maturity. The “What?” and “Why?” questions on the table, were also said to be confusing. One of the subjects complained about completing it individually. He argued that it could be more effective as a collective method. Another complain about this method was that it was not a good guide, which can converge you through some definite goals.

- **FCM table:** Subjects commonly blamed this method for being too complex to be use collectively. The subjects argued that there were many discussions on the real meanings of the terms “function”, “criteria” and “metric”. Especially in Exp-2, the subjects commonly mentioned that these terms were really complex to interpret, because of that they lost so much time on their clarification during the meeting. On the other hand, this method was considered to be more effective compared to 5W table in terms of structuring and representing the ideas in a proper way. However, the subjects criticized the fact that they could not show the links between the functions. Furthermore, they claimed that they had also difficulties to decide, to which level of detail they would describe on the functions. In other words, too general functions could be listed, as well as very specific ones with great details. The necessity to add sub-functions was raised in some groups and they added a new column on the FCM table to list the sub-functions. Moreover, one of the subjects supported the idea that the functions and solutions co-evolve collectively, so that FCM table could not be completed as a whole in the early stages (which was also discussed from the literature in chapter 2, section 4.5.2). Another interesting point mentioned by one of the subjects (member of group A) was that the method guided the way they thought. He mentioned that the FCM table guided them to think in terms of the functions. He underlined that if the intended users were integrated to the process, they would not think in this way. For example, they would ask for "a yellow" product, instead of talking about the product functions. Similarly, another subject pointed out that by discussing around the functions, they have almost forgotten to discuss about the usage and the environment context, in which the product is going to be used. This was a missing point in the FCM table.

- **Scenarios:** were described as an effective method to create empathy with the intended users, understand their needs and liberate one self upon thinking about his own needs. It was supposed to stand for an icebreaker in the group to start the preliminary conversations and keep the good ambiance alive. They were identified as effective to narrow the vague

product definitions and target specific goals. Nevertheless, similarly with FCM table, they were accused of not being clear about, to which level of detail you will go through when you describe them. Another underlined point was that they considered scenarios as a discussion method, a way to represent what they thought, so that they did not feel the necessity to capture them.

- **Personas:** were seen as a starting point for scenario creation. The effectiveness of the personas was attributed to the scenarios created around them. Personas were argued to keep intended users more visual, and as a result of this more alive; so that intended users play an important role in the way the product is designed. Moreover, the subjects qualified personas as useful to consider the points of view of different intended users they represent. In the contrary, they were also found restrictive, because subjects were limited by the created personas, which might be not enough to represent the whole user population. They underlined the fact that one could not define so many personas during a simple project. They also highlighted the importance of the persona choice, which means, whether you have chosen the right persona, would affect your whole list of requirements, and eventually the success of the product.

9. Concluding Remarks

We can summarize the results gathered in this chapter as follow:

- **The design groups have difficulties to converge:** Section 2 points out that in each group, the subjects have difficulties to converge to a common perspective on the product. For example, Table 23 shows that in none of the groups all of the subjects list the same function in the first order. Moreover, Table 24 demonstrates that there are only two design groups that obtain substantial positive correlation and any of them almost perfect positive correlation. Similarly, Table 25 and Table 26 highlight that the subjects cannot converge to a common picture of the product. These results underline the importance of the research studies on this obstacle.

- **The design actors have difficulties to clarify their perspectives:** Similarly with the convergence, we noticed in section 3 that the subjects have difficulties to clarify their perspectives. In other words, the subjects were not aware of their agreements and disagreements within group. For example, while subject 1 (in Exp 2 group B) believed that his ranking order would be different from others subjects' ones, he had almost perfect agreement with subjects 2 (with the correlation coefficient=0,98). That underlines the fact that even though designers

might think that they clarified their perspectives, the others might interpret these perspectives differently.

- **In design meetings, the subjects naturally use fragment scenarios,** in order to discuss about the user goals and the desired effects of the products. We noticed that in group A there were also many created fragment scenarios. Telling anecdotes is a common thing that people use frequently without giving so much attention. That is why people have difficulties to see scenarios and personas as real scientific methods. However, the advantage of these methods is that they support this necessity to tell a story while communicating. They give the necessary rules to create these stories collectively and keep the discussion around them. They intensify this process of story creation and usage.

- **The major impact of personas is to evoke the empathy:** The results show that personas are effective methods to create empathy for the users. In the absence of the personas, the subjects have tendency to focus on their own needs, while the personas help them to build “him/her story”, instead of “I story”.

- **Scenarios and personas enrich the discussions:** When we compared the numbers of discussed functions in each group, we noticed that the group that use these methods was more effective compared to control group.

- **The scenarios and personas play the role of “icebreaker” within the group:** The scenarios and personas play the role of “icebreaker” in the meeting. They create a good ambiance that the subjects have no difficulties to keep the conversation going. Because they are talking about imaginary people, the subjects feel more confident to give their ideas, make jokes about personas, criticize their characteristics, etc. The results of the analysis conducted in Exp 2 also show that there are less awkward silences in the group that use these methods than control group.

- **The scenarios and personas are promising to capture of design rationale:** The results show that the capture of scenarios can help subjects to keep trace of the rationale behind the taken decisions. However, in any of the groups the created scenarios are captured (despite of our request). The subjects consider these methods more as a discussion tool than documentation one. The study carried out in Exp 2 demonstrates that, even if the group B was more effective in terms of the richness of the discussions, the captured data at the end of the meeting were similar.

- **We cannot demonstrate that there is a significant impact of scenarios and personas on the convergence of the perspectives:** As discussed in section we got contradictory results in terms of the convergence of the subjects to common perspective on the fundamental functions

of the product. Moreover, we cannot explain the reasons for what the subjects of group A in Exp 3 converge to a more common function list compare to all other groups without using these methods. Similarly, the section shows that subjects of group B in Exp 1 and Exp 2 did not converge to more common 5W tables, compare to the subjects of group A. The convergence on the FCM table was also not helpful to deduce a conclusion, because the convergence was more or less the same in groups A and B. However, the qualitative analysis demonstrates that as a communication tool these methods are effective for argumentation and negotiation between design actors. In conclusion, in this research study we have not enough elements to conclude that these methods have a significant impact on the convergence of the perspectives. This might be caused by the fact that we have only three complete experiments. The same study has to be carried out several times to gather more definite answers. New indicators that will give us more insights also can be investigated.

- **We cannot deduce the conclusion that the scenarios and personas have a significant impact on the perspective clarification:** Similarly with the convergence, the results of the study on the perspective clarification shows that the level of awareness between subjects change in different experiment groups. However, the groups that use these methods, have not remarkably better results in terms of the awareness about their agreements and disagreements on the ranking table, to conclude that these methods have a significant effect on the perspective clarification.

- **The impact of scenarios and personas on the requirement elicitation:** When we compared the listed numbers of functions in each group, we perceived that the group that uses scenarios and personas has not necessarily better results compared to the control groups. In other words, even in their absence the subjects have the same performance in terms of the number of listed functions.

- **The vague definition of scenarios prevents the subjects to use them effectively:** One of the commonly discussed disadvantage of the scenarios during the interview step was that the definition of the scenarios is too vague that the subjects do not know to which detail they will go in scenarios. This arises the questions of what a real scenario is and how a fragment scenario becomes a real scenario, that we have not the answer yet.

- Some other deductions of the research study, which are not directly related to the research questions are discussed in appendix 16.

In conclusion, in this chapter we discussed the results of the analysis phase. The next and the last chapter discuss the contributions of this research study.

Chapter 8 Conclusion

In this chapter, the contributions and limitations of this research study are presented. Finally, the possible future steps are discussed.

1. Conclusion

In this research study, we focused on two main obstacles that can be faced during the requirement elicitation activity: problem of understanding between design actors and problem of understanding intended users' needs. The literature review on the scenarios and personas showed that these methods could be promising to deal with these obstacles. In order to evaluate the impacts of these methods, an experiment was designed and conducted. Some indicators were proposed to measure the impact of these methods. The data gathered from the four experiments (seven design sessions) were analysed. There were two main contributions of this research study. On the one hand, we evaluated the impacts of these methods to handle the above-mentioned problems. On the other hand, we exercised the experiments as an engineering design research methodology.

- 1) The impacts of scenarios and personas in requirement elicitation:

In this study, the impacts of scenarios and personas on requirement elicitation activity were evaluated. In the following, we discuss the findings.

Problem of understanding between design actors: Problem of understanding between design actors was treated under two sub-categories: perspective clarification and convergence to a common perspective. The results of the research study show that as a communication tool scenarios and personas are powerful to clarify the arguments, to negotiate and to take decisions. However, the subjects of the groups that used these methods were not distinctively more aware of their agreements or disagreements, or significantly more converged to a more common vision of the product, compared to the subjects of control groups. That means there were other factors in control groups, which had more impacts on these aspects, rather than scenarios and personas. Even if there is still much research to do before the achievement of an exact conclusion, the presented research study showed that we have not enough elements to prove that these methods have a significant impact on the creation of shared understanding between design actors.

Problem of understanding intended users' needs: Problem of understanding intended users' needs are discussed under three sub-categories: requirement elicitation, capture of the design rationale and creation of empathy.

The findings demonstrate that the design actors naturally use fragment scenarios, in order to discuss about the user goals, the desired effects of the products and other characteristics of the product. The advantage of scenarios and personas is that they reinforce and intensify the creation of more complete scenarios collectively and keep the discussion around them. In that way, they ensure keeping the conversation going and create a good meeting ambiance. The results of the study also point out that scenarios and personas enrich the discussions in design meetings. Significantly more intended users' needs were discussed in the groups that use these methods compared to the control groups. However, at the end of the meeting, when we compared the listed requirements, we cannot conclude that the groups who use these methods were more efficient.

Moreover, the results of the study point out that the capture of scenarios can explicit the assumptions and decision-making criteria in requirement elicitation activity. Although the subjects were built and used many different scenarios, none of them were captured. Except some sketches, which have no meaning for external people, there was no trace of the created scenarios. However, the created personas were captured. This can be partially explained by the fact that the provided tools (based on a PowerPoint framework) were not suitable to scenario capture.

Finally, the results also show that personas change the way of thinking of the design actors, in that they evoke a strong focus on intended users. In other words, they provide the creation of empathy for the intended users. Most of the requirements are elicited either based on the characteristics of the personas, or scenarios created around them. Hence, the scenarios and personas are guiding the requirement elicitation process. Personas also highlighted conflicting requirements, which can be essential for a persona, but disturbing for another one.

To conclude, different impacts of the scenarios and personas are presented and interpreted in this study. The results show that while these methods can be used to deal with the second problem, we couldn't prove that they are useful to handle the problem of shared understanding between design actors. It is important to conduct similar studies on other design methods. Hence, the design actors can choose the more appropriate methods according to their objectives.

- 2) The experimental study as an engineering design research method:

The research study shows that the experiments can be used as an engineering design research methodology to gather useful insights and deeper understanding about design activities. They can be used to evaluate effectiveness and appropriateness of existing design methods. A structured research approach, which explains how to design, conduct, evaluate and analyse an experiment, is discussed in this study. Clearly, the observation of design meetings ensures a good understanding of the design methods, which can in turn be used to provide training, feedback, new methodologies and tools to the design teams. However, the analysing process is too much time consuming and overwhelming.

Thus, the pre-test and post-test measures are discussed as a complementary approach to the design meeting observation. The findings demonstrate that indicators gathered through pre-test and post-test measures, can give good insights about perspective clarification and convergence of subjects. We can conclude that these measures can be complementary to the design-meeting observation. However, to be able to gather more robust results with these measures, we have to carry out the same experiment several times. In our research study, because we have only three complete experiments, in the case that there were contradictory results in each group, we could not deduce a conclusion. Nevertheless, for now, we cannot be capable of conducting that much experiences, because of the many different constraints such as time, finding suitable subjects, finding enough people to analyse the results, etc. Another shortcoming of these measures is that they do not give integral information about what is going on in the meeting. For example, we noticed that even if the groups listed similar number of requirements, the groups that used scenarios and personas discussed significantly more number of intended user needs. Hence, we can infer that these measures can be complementary to the design-meeting observation, but not replace them.

2. Limitation of the study

The results of the study described in this research study have to be viewed in the light of the limitations that are inherent to the setup of the study and to the analysis methods.

- Because the experiments were conducted in the laboratory environment, as discussed in the Chapter 4, section 3.1.1 some tradeoffs are faced. They were limited with the furnished materials and worked in a laboratory environment that might be in some ways different from the real work environment. For example, we observed the subjects' necessity to use Internet, which was banned in the research study.

- We noticed in this research study that in group B, although the subjects discussed many fragment scenarios, they did not create complete scenarios and represent them through a representation as asked in the briefing (which was recommended in the literature Chapter 3 section 2.2.1). So, they used the methods scenarios partially, not integrally. Thus, our findings might be influenced by this side effect. In companies, designers commonly have this problem that they refuse to use new methods or be informed about them. One of the expert designers who participated to our experiment mention that *“if you run the same experiment with the same people tomorrow, if you don’t ask them to use today’s methods, they won’t use, although the method is really useful”*. Using animators, who are trained about these methods, might eliminate this shortcoming in the groups. Hence, we wouldn’t need to realise extra analysis to be sure that whether the groups use these methods.

- Because of the time constraint some of the gathered data were not analysed in depth. While we conducted integrally the analysis of the data gathered from Exp 2, we couldn’t follow the same process for the other experiments’ data. In the case that all the gathered data are analysed, we might get new insights and aspects that they might reinforce our assumptions.

- The indicators that are proposed in this study are also open to the discussion. In appendix 15 we listed some of the detected strengths and shortcoming of these indicators.

- As discussed in Chapter 7 in section 2.3, the notion of convergence is also a point of questioning. We described the notion of convergence as converging to a common perspective. However, we noticed that while populating the FCM table, the subjects converged to a common representation of the product without changing their perspectives. In other words, the subjects accepted the ideas of the others, without agreeing with the idea. In this research, we did not focus on this aspect.

3. Future Steps

This research study has elicited a number of possible new research fields to investigate. In this section, we discuss about our perspectives and possible future steps following this research study.

Problem of understanding between design actors: The findings show that the design teams have a real difficulty to clarify their perspectives and to converge to a common one during the design meeting. After one hour and half meeting to perform functional analysis, the subjects were generally not aware of their agreements and disagreements on the functions, and

also did not have a common vision of the fundamental ones. These results highlight the importance of the researches conducted on that obstacle. For further researches, we can more focus our attention on this issue.

As a first option, we can carry out new research studies to determine the impacts that reinforce the perspective clarification and convergence in design meeting. As a first step, we can perform a detailed analysis on the video recordings of the design meetings to investigate these impacts. Especially, in Exp 3, a more detailed analysis can be conducted on the video recording of the group A, which was more effective in terms of the convergence compared to other groups. With the guide of what is learned in the present study, new experiments can also be designed and conducted to gather more findings. These results either can be used to improve the scenarios and personas, or new methods and tools can be designed.

On the other hand, we can focus our research studies on the supporting tools that can give feedbacks to the design actors about their level of shared understanding. In this study some indicators are discussed and used. New indicators can also be determined with future studies. The relevance of the proposed indicators has to be validated deeply in other contexts and other protocols. Once the indicators are completely validated, one can imagine proposing a tool for supporting the shared understanding between design actors. For example, IT tools or collaborative design software can perform automated identification of the level of shared understanding within the group. In that way, the supporting tool can give these indicators as a feedback to the design actors after the design meetings to disclose, how much they converged to a common perspective, or how much they were aware of their agreements and disagreements, etc. For instance, the indicators such as Spearman's rho can be really helpful in companies to show the convergence and divergence about the importance given to the requirements by each design actor.

Problem of understanding intended users' needs: As mentioned before, scenarios and personas increase the intended user focus and awareness. Characteristics of the personas and the scenarios created around them guide the requirement elicitation activity. However, the subjects of the experiments commonly claimed that the provided materials were not ergonomic and flexible enough to create, use and capture of scenarios and personas effectively. We also noticed as an observer the necessity of more interactive tools, which can help design actors to benefit from these methods more effectively during the design meetings. We realised a brief literature review on the existing tools that are discussed in the literature (see appendix 14). It comes from this review that very few tools exist that support interactive creation, use, capture of scenarios, which shows the necessity to concentrate on this problem. One of the ideas that can be further

developed is that the personas prepared beforehand in the form of small cards, can be used for a card game. The designers can pick one persona randomly and create scenarios around it. For each persona there is time limit to be respected. For the scenarios, presence of a cartoonist can also be useful.

Research Methodology: The observation ensures a deep understanding of the design activity, which can in turn be used to support design actors. However, it is commonly accepted that it is too much time consuming and overwhelming. Thus, the research teams from different universities (University of Grenoble, University of Bath, Luleå University of Technology, University of Zagreb, University of Turin and Stanford University) are created the International Design Observation Network (named iCORE) to work on the idea of an “Intelligent design observatory”. With the idea of the intelligent design observatory, we switch to an active observational environment, in which the interventions (e.g. pushing images of potential solutions) can be made in a time-scale that has an effect on the outcome of the design activity (Hicks et al. 2008, Hicks, et al. 2009). The researchers also organized workshops and summer schools (Luleå winter workshop¹⁶ and IDON summer school¹⁷) to train the PhD students on how to conduct an observational study and how to monitor, capture and analyse the data. The knowledge gathered in this research study can be used to focus on this “intelligent design observatory” idea.

¹⁶ Luleå Winter Workshop. 17 – 21 November 2008. Luleå University of Technology, Sweden.

¹⁷ IDON Summer School. 5-10 July 2010 University of Grenoble, France.

Chapter 9 Appendices

In this chapter, the appendices are listed.

1. Function, Form, Feature

In the literature it is not clear what the differences are between the terms form, function and features that describe a concept. Wood and Ullmann (Wood and Ullman 1996) define the features as “*the primary building blocks of a structure, i.e. the specific geometrical forms that satisfy the functional needs pertaining to a component*”. From this definition, we can conclude that the authors match the feature with specific geometrical forms. On the other hand, the function are described as « *the behaviour or action that the feature must satisfy in order for the product to achieve its overall purpose* ». They remark that function describes then the intent of the feature as seen by the designer. We can conclude that in simple words a feature is what the product has, while as a function is what the product does. However, in other resources the term feature is used in a broader sense. Ulrich and Eppinger (Ulrich and Eppinger 2004) along with not giving an accurate definition of what they mean by feature, they listed some of the features of a screwdriver as an example (pp.67):

- “*Screwdriver can drive screws into hardwood*”
- *Screwdriver has a pleasant sound when in use*”

While the listed first feature can be categorized as a function of the product, the second one can be accepted as non-functional need (or a positive affordance according to). From this point of view, features are the user needs. Features are also commonly used to refer the user tools inherent in the product to perform functions (Coulin 2007). For example, when we talk about the features of a cell phone, we list the features such as messages, alarm clock, etc. These features perform many functions, for example the message feature performs the functions: record, update, display, etc. However, in this point of view, feature is not the expression of the need, but the way that it is satisfied. Because, in the given example the need is not to send a message, but to communicate in a cheap and easy way in the written format, which can be satisfied through another features like as e-mail. In this study, in order to prevent the confusion with the terms need, solution and feature the term feature used in a narrow sense to label the form of the product, and the term function is detailed in Chapter 24.5.1.

2. Global look on scenario usage

Scenarios have a broad application area apart from design such as strategic planning, decision-making, security, ergonomic, etc. Thus, in this section, before talking about the scenario usage in design, we will make a general overview on how and what for they are used in some of these domains.

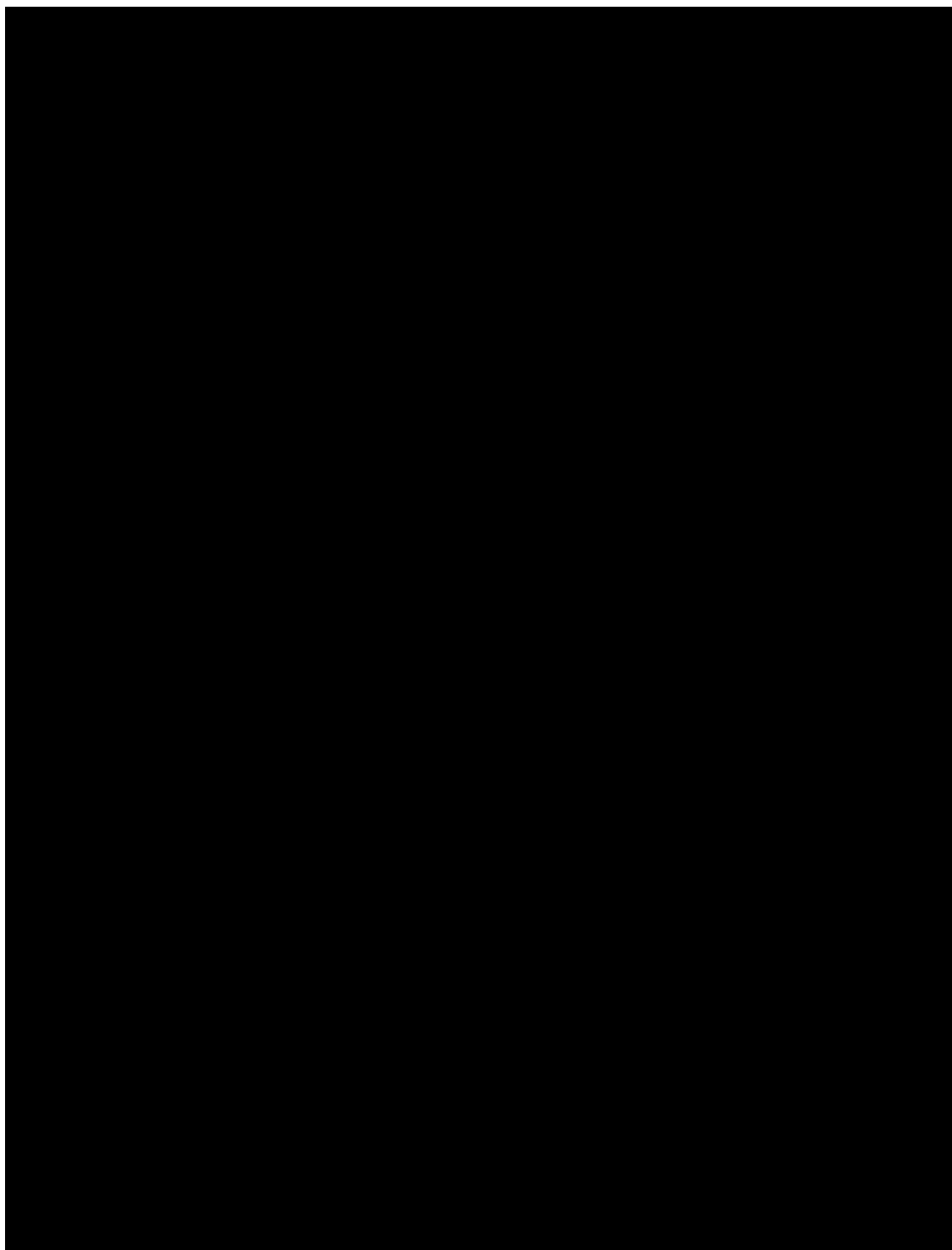
In the business management, scenarios are commonly accepted as a tool to help decision-making in an organization. Kivijarvi, et al., (Kivijärvi et al. 2009) argue that scenarios enable to convert personal knowledge into organizational knowledge in order to increase the quality of decision-making. They describe the knowledge as “*the individual and organizational ability to make decisions; all actions are consequences of decisions*”. They define three main roles of the scenarios in an organization: 1) *Scenarios as a process*: is a learning exercise about the present. That orients the organization members through a critical discussion about the present situation, its drivers and evolution; 2) *Scenarios as projections of future*: is to create and clarify the assumptions about the future and represent the knowledge gathered; 3) *Scenarios as stories of plausible futures*: representation of the projected scenarios, that construct a framework to reflect on the existing knowledge and mental models and their adaptation in different environments. Likewise, Chermack (Chermack 2003) defines four main failures that impact decision failure: bounded rationality, tendency to consider only external variables, stickiness and friction of information and knowledge and finally mental models that include decision premises or policies. He argues that scenario planning might be used to deal with each of these failures. Moreover, Snowden (Snowden 2000) argues that the utilization of the stories in the organization provides shared values and rules that will increase the trust between the members and enable the self-organizing capability in the face of an uncertain situation. The author gives the example of the religion, which is also diffused by the intermediary of the stories. These stories created the common values and rules between the believers that guide the taken decisions even in the absence of the storyteller. Chermack and Merwe (Chermack and van der Merwe 2003) also highlight the theoretical link between the scenario planning process and the constructivist learning and teaching perspective. The authors argue that scenario planning provokes a strategic conversation between decision makers and challenge their existing assumptions and enable organizational learning.

Additionally, Suri and Marsh (Suri and Marsh 2000) mention that the concerns of the ergonomics previously were limited with the ensuring the product's safe, usability, effectiveness and facility in learning, which are mostly functional performance issues. However,

with the growing competitiveness in the market, beyond functional concerns they are also asked to comment on the emotional, experiential aspects. Then, they head their analysis toward the users' interactions with product. The authors describe scenario building as an ergonomics method in consumer product design. They claim that scenarios combine the human and technology issues, which provide the communication and the evaluation of qualitative aspects of the product in the early stage of the process. For the users' satisfaction, not only the functional concerns, but also the product's attributes such as look, feel, smell, image, etc. and the reactions that they will evoke on the user come into question, which can be expressed by scenarios.

Scenarios are also commonly used in security. Especially in military, scenarios ensure managing risks and menaces (Marguin 1999). According to Marguin, scenarios can be used, not to foretell the future events, but to predict the results of our present actions on the future and to choose the ones that will finish the way we want. Marguin in his book gives the examples of methods that can be used scenarios effectively in security. After this global look on scenario use in other domains, we can conclude their main role is to describe actual situation and predict the future ones. In that way, they help the decision-making within a group. In the following, we realize a detailed analysis of scenario use in design.

3. Video Consent Form



4. Training Document

Below, the formation document, which is furnished to the subjects of Group B four days before the experiment via e-mail, is presented. Group A's subjects also get the same training document, but it does not contain last two sections, which are related to the scenarios and personas.

Training Document:

We really appreciated that you have accepted to take part in this scientific experiment in which we try to evaluate different kinds of design methods. This document is prepared to explain to you the methods that you are to use during the experiment.

The 5W table (Who, What, When, Where and Why)

The 5W method is easy to use; it consists of asking the five questions (Who, When, Who, Where and Why?) to derive ideas. This tool helps designers to collect and criticize information. Repeating these questions allows rapid definition of the needs. These needs are the fundamental objectives to be met by the product and consequently the objective of the design study. These questions are one of the first steps to follow before going further in product design process.

- Who (is concerned, actor, responsible,...) ?
- What (object, action, phase, operation,...)?
- When (moment, planning, time, frequency,...) ?
- Where (lieu, distance, stage,...) ?
- Why (to realize that action, respect this procedure,...) ?

Example: Bike lock

	Questions to be asked	Answers
WHO ?	For whom it is designed? ...	<ul style="list-style-type: none"> ▪ For all cyclists: professional cyclists, urban cyclists etc.
WHAT?	What is it for? What characteristics must have a bike lock? ...	<ul style="list-style-type: none"> ▪ Lock the bike to a fixed point (like a tree, etc.) ▪ Must be adaptable to the different places that we want to lock our bike ▪ Must be light ▪ ...
WHEN ?	When do we use the bike lock? What is the frequency of use? ...	<ul style="list-style-type: none"> ▪ Whole day: when we have to park our bike ▪ Each time that we must leave our bike somewhere ▪ ...
WHERE ?	Where do we use the bike lock? ...	<ul style="list-style-type: none"> ▪ Urban environment (school, swimming pool, etc.), in the bike parking area, etc. ▪ ...
WHY?	Why do we use the bike lock? What are the reasons? Consequences, causes, effects? ...	<ul style="list-style-type: none"> ▪ In the absence of the bike lock, bike risks being stolen. ▪ ...

The Function-Criterion-Metric Table

Functions:

Function analysis is a systematic method used to describe the needs that a product, system or process should meet to satisfy the user. Function is “the action of a product or one of its constituents expressed in terms of finality”. It takes into account *the result* and *not the solutions* that allow that result to be obtained.

It is rare that a product fulfils just one function. The product is an assemblage of defined functions. For example one of the functions of a bike lock is to resist to the robber’s attacks however other functions can also be listed such as: be easily handled, be adaptable to all kinds of bikes, resistant to weather, etc.

Designation of a function must be clarified to avoid misinterpretation. Therefore the use of one verb and a complement is recommended, for example: resistant + to the robber’s attacks.

Merely a designation is not sufficient for characterising a function; so you need to add the characteristics listed below:

- Number of the function
- Designation of the function
- One or more appreciation criteria of the function (see below)
- Metric of each appreciation criteria (see below)

So, we can represent a function:

N° :	Designation of the Function	Criterion	Metric

Appreciation Criteria:

These are the criteria used for appreciating the way that a function is accomplished or a constraint respected.

E.g.: As we mentioned before one of the functions of a bike lock is to be easily handled. The assessment criteria of that function can be described as:

- Its weight
- Its time to set up
- Its availability

Metric:

Metric is the scale adopted for an appreciation criterion of a function. These metrics may be the objective to be achieved or the defined level for a proposed solution. The metric is usually defined by a numerical value for the « objective » criterion and a reference for the « subjective » criterion.

For example the metrics for the appreciation criterion of the function « be easily handled » are:

- Weight < 300g,
- Set up time < 5s.
- Be available all the time

Using the same example, here is a part of the function-criterion-level table for the bike lock:

N° :	Designation of the Function	Criterion	Metric

Persona

The Persona is a fictitious user, representing a class of users. A Persona may have:

- name, age, sex, photo, etc.
- similarities to people you know, habits, profession, friends, animals, etc.

- ethnic origin, educational background, socio-economical state, etc.
- history, goals, tasks, etc.

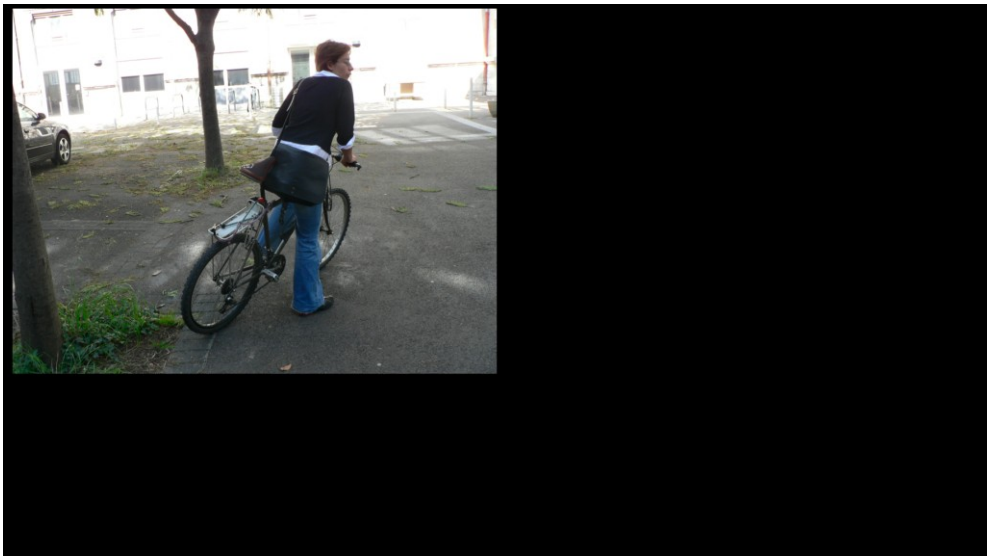
Personas are **hypothetical archetypes of actual users**, defined and differentiated by their goals. Personas allow designers to develop a common vision of a product's end users. This vision provides a common reference point for all stakeholders of the design process. Personas help designers to move from many conflicting goals unorganised to a clear set of Personas, each with a **well-articulated set of goals**. Focusing on Personas goals, their expectations and their potential restraints allows designers to establish their priorities and guide the decision making process.

For a simple design project several Personas may be used simultaneously by differentiating their goals (1st), their roles (2nd), their behaviours (3rd), etc. During the project the importance given to different Personas may vary. There may be a primary Persona whose needs must be satisfied principally and also secondary Personas.

The Persona must be realistic. Due to this requirement for realism they are generally based on ethnographic studies made on the target market.

Here is an example: If you are designing a bike lock for young people, it would be easier to focus on the goals of Persona Léa; when will she use the lock, where will she use it, what does she need, what is her aim in using it, etc. In answering these questions the needs of the target market represented by her will be satisfied.

Example: Persona Léa: Bike lock user



Scenarios

Scenarios:

- Are histories of people and their activities
- Have the characteristic aspects: context, actors, goals/objectives and sub goals
- Include sequences of actions and events

During design projects generally two types of scenarios are used:

Scenarios that describe the actual situation: These scenarios allow designers to identify the convenient and inconvenient of the existing situation and focus on the improvements that have to be done.

Projected Scenarios that describe the potential future use of an innovative product under development. These scenarios show how actual situation may change because of this new product. These scenarios do not necessarily explain the technology to be used by the product; instead they focus on the end user activities and product functionalities.

Scenarios may be represented in different forms such as: texts, storyboards, films, cartoons, animation, theatrical performances, etc. **Scenarios create the life of a Persona, showing them in action.**

Example : Bike lock

Textual representation of an actual situation: Léa goes to university generally by bike. Her bike was stolen last year so she now is very focused on her new bike. She currently uses an attack resistant bike lock. Once she leans her bike against a fixing point, she has to leave her stuff on the ground to liberate her hand and bend down to lock her bike. It is not a complicated procedure, but repeating it each day is not practical. It is especially inconvenient on rainy days where she must find a dry place to put her stuff while using the lock. It is also problematic when she needs to leave her bike for a short time, for example, buying a journal etc.

By analysing this scenario describing the actual situation, we can identify the end user needs. First of all the product has to be resistant to attack and at the same time it has to be installed simply with a easy action. Thus the designers may focus on a concept that will satisfy these needs.

Example of projected scenario: As mentioned before a projected scenario describes how the actual situation may change by a new product design.



Léa leans her bike against a tree, without leaving her stuff and without bending down; she secures her bike by tying the lock around a tree.

5. The Manager's Role

In addition to the training document, the manager of the meeting is also provided with a specific document to explain his/her responsibilities in the meeting. In the following, this document is presented.

The Manager's Role

Thank you for performing the manager role during this group working session.

Manager is the leader of the meeting; his role is to drive the group work, bring together the ideas, federate the participants and make sure that the results will be obtained at the end of the limited time.

As the manager of the meeting,

- * You are going to move the team towards the objectives of the meeting
- * You are not going to monopolize the meeting by interrupting the other participants
- * You are not going to impose your points of view but you will submit them as a proposition. Each member including yourself has equal weight in terms of idea value.

In summary we can list your missions:

1) Production (**result**): make the meeting and team effective, guide the team to produce the results; that means the solutions, decisions, propositions and information, etc.

2) Organisation (**structuring**): encourage the whole group to express their point of view in a structured way, organize and arrange the expressions

3) Management (**manage the individuals, the interactions and the time**): manage the relations between the group members who will react according to their status, personality, etc. and manage the time.

Good luck

Thanks

6. Preparation Phase Briefing



Task 1.1: Preparation for the group meeting

A meeting with your project team will be held to formalize the specification of the digital calendar to be designed.

In order to prepare for this meeting, you are asked to complete a 5W table related to the defined problem.

Available resources:

- A computer with an Excel table to be completed (you are free to add columns or rows)
- Draft Papers

You have 20 mn to complete the table

Good luck
Thanks

7. Design Meeting Briefing



Task 2.1 Specification formalisation

You are a design group tasked with designing a digital calendar. The objective of this meeting is to establish the specifications of the digital calendar by using a scenario based approach that will be used as a basis for the design process. As a manager of the meeting you are asked to ensure the realisation of this objective on time.

At the end of the meeting, you have to furnish us with:

- A PowerPoint presentation of the Personas and scenarios created,
- A Function-Criterion-Metric table

Available resources:

- Two computers coupled to two video projectors
- An Excel table to be completed
- A PowerPoint file to be completed
- Draft papers
- A library of images that you can use for Personas and scenarios

You have 1hr30mn to complete this task. You will be informed 30mn before the end of the meeting

Good luck
Thanks

8. Importance of the different functional requirements



Task 3.1- Importance of the different functions

Following the meeting, you are asked to rank the functions defined by the design group according to their level of importance.

To do this task, you have an Excel table, in which you will rank the 5 functions (that you consider most important) from most important to least important.

Then you will assign a relative weight expressed by a percentage.

Available resources:

- A computer and a Excel table,
- Draft papers

You have 5mn to complete the table.



The total of the percentage of the functions has to be equal to 100.

Good luck
Thanks

9. New vision of the problem



Task 3.2 Your new vision of the problem

You are asked to fulfil again a new 5W table related to the design idea: digital calendar.

Available resources:

- A computer and a Excel table (you are free to add column and rows),
- Draft papers.

You have 10mn for fulfilling the table

Good luck
Thanks

10. Interview Questions

Interview questions: In the following, the list of the questions that are asked to subjects are presented. Although all the group subjects are interviewed with the same question, the question 8 and 9, which are related to the scenario and persona approaches, are asked only the subjects of the Group B.

1) In the Function-Criterion-Metric table that you have completed as a group, do you agree with all the functions defined? If not what would you do different?

Clarification of question 1 (question 2 and 3):

1.1) Are there any missing functions? Which ones?

1.2) Are there any unnecessary functions? Which ones?

2) In the Function-Criterion-Metric table that you have completed as a group, do you agree with all the criteria defined? If not what would you do different?

Clarification of question 4 (question 5 and 6):

2.1) Are there any missing criteria? Which ones?

2.2) Are there any unnecessary criteria? Which ones?

3) In the Function-Criterion-Metric table that you have completed as a group, do you agree with all the metric defined? If not which kind of differences will you do?

4) In your view, in the priority table that you have completed individually **is the order of** importance of the functions shared by the group. If not in which where are differences in importance level?

5) In your view, in the priority table that you have completed individually **is the related weight of the functions** shared by the group?

6) Do you think the proposed tools (5W and function-Criteria-Metric table) were relevant to help to formalize the needs of the end users? If yes, explain why? If no, explain what was missing from these tools?

7) In your view, does the FCM table allow the translation and capture of all the end user needs?

8) In your view, what were the advantages or disadvantages of using scenarios for the construction of specifications? Do you have any other comments on the use of scenarios?

9) In your view, what were the advantages or disadvantages of using Personas for the construction of specifications? Do you have any other comments on the use of personas?

10) Can you describe the product?

11. Critical Values of the Spearman's rho

The table below shows the critical values of the Spearman's rho. Calculated rho must equal or exceed the table value for the significance at the level shown.

Level of significance for a one-tailed test				
	.05	.025	.01	.005
Level of significance for a two-tailed test				
	.10	.05	.02	.01
$N = 4$	1.000			
5	.900	1.000	1.000	
6	.829	.886	.943	1.000
7	.714	.786	.893	.929
8	.643	.738	.833	.881
9	.600	.700	.783	.833
10	.564	.648	.745	.794
11	.536	.618	.709	.755
12	.503	.587	.671	.727
13	.484	.560	.648	.703
14	.464	.538	.622	.675
15	.443	.521	.604	.654
16	.429	.503	.582	.635
17	.414	.485	.566	.615
18	.401	.472	.550	.600
19	.391	.460	.535	.584
20	.380	.447	.520	.570
21	.370	.435	.508	.556
22	.361	.425	.496	.544
23	.353	.415	.486	.532
24	.344	.406	.476	.521
25	.337	.398	.466	.511
26	.331	.390	.457	.501
27	.324	.382	.448	.491
28	.317	.375	.440	.483
29	.312	.368	.433	.475
30	.306	.362	.425	.467

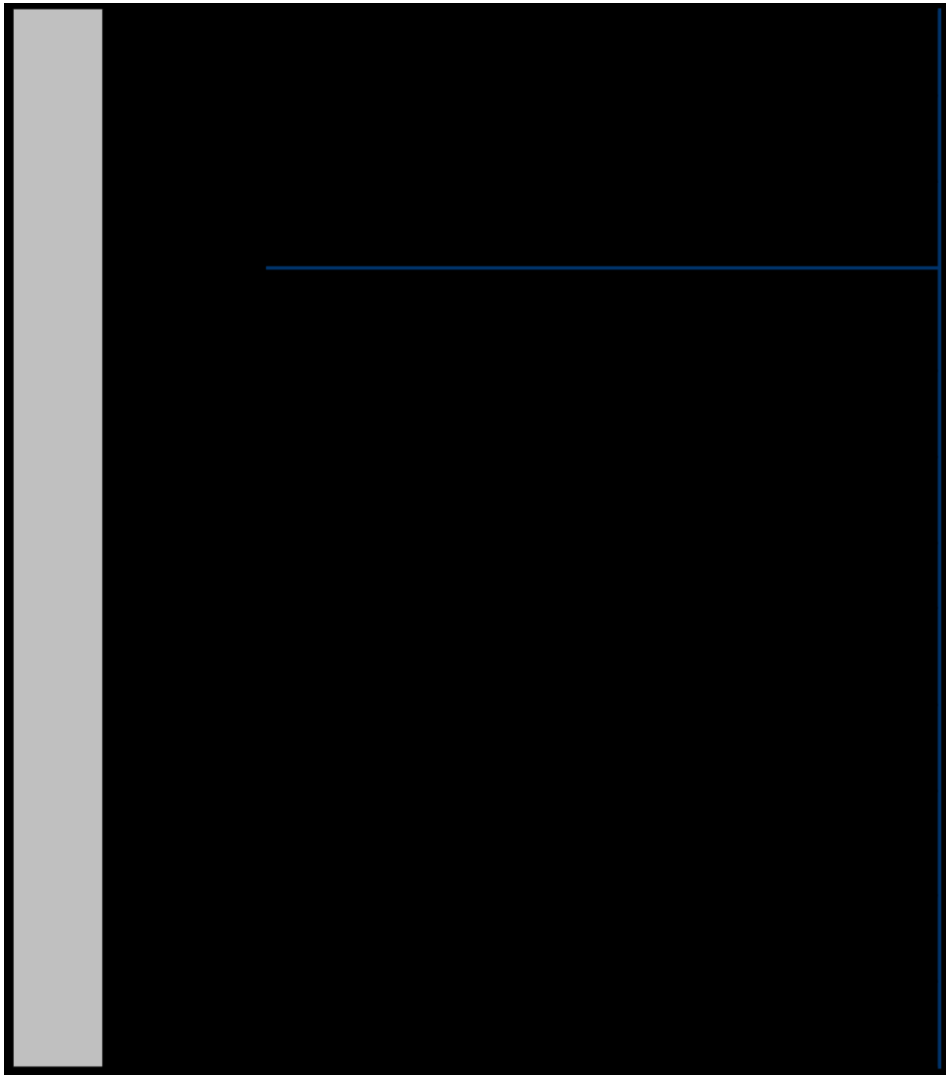
Table 32: The critical values for Spearman's Rho (Zar 1972)



Quand?	

Où?

Pourquoi ?



13. Function Lists of Each Group Experiments

		Exp-1		Exp-2		Exp-3		Exp-4
Functions		Group A	Group B	Group A	Group B	Group A	Group B	Group B
F1	Arrange events/tasks			X				
F2	Track conflicts			X				
F3	Manage individual time			X	X			
F4	Manage project			X	X			
F5	Track special days (like holidays, counts days)			X				
F6	Assign priorities			X	X		X	
F7	Notify updates			X			X	
F8	Display (e.g.fields)	X		X		X	X	
F9	Check availability (of people, ressources)			X				
F10	Encourage social interaction			X	X			
F11	Remind (special dates, hours, etc.)	X		X	X			
F12	Allocate (tasks, ressources, etc.)			X				
F13	Track (progress, ressources, etc.)			X				
F14	Forecast (progress, ressources)			X				
F15	Motivate towards a goal			X				
F16	Send information (memo, request, etc.)		X		X		X	
F17	Track modification				X			
F18	Support multiple-languages				X			
F19	Stock information	X	X			X		X
F20	Synchronize	X		X		X		
F21	Export data				X			
F22	Import data				X	X		
F23	Support different user profile (Filter information display, according to user profile, according to users' choice, etc.)	X			X	X	X	
F24	Support different format (pdf, word, voice, etc.)		X		X	X		
F25	Avoid missing events			X				
F26	Notify remotely			X	X			
F27	Highlight conflicts				X			
Total		5	3	18	14	6	5	1
User Goals								
U1	Input data (events, etc.)		X	X			X	X
U2	Confirm attendance			X				
U3	Modify				X		X	
U4	Organize an evenement	X					X	
U5	Consult planning					X	X	X
U6	Retrieve (existing events)			X				
U7	Share (data, media, etc)				X	X		
U8	Upload data	X			X			
U9	Download date				X			
U10	Delete or stock manually	X						
Total		3	1	3	4	2	4	2
Others								
O1	Compatibility (other calendar types)	X		X				X
O2	Immediacy (speed)	X	X	X	X	X		X
O3	Easy to use	X			X		X	
O4	Fun to use				X			
O5	Robust	X	X		X	X		
O6	Accessability (restricted access)				X	X	X	
O7	Customisable				X			
O8	Easy to fix and deplace	X	X					X
O9	Aesthetic	X			X			
O10	Screensaver	X						
O11	Stand by mode	X	X					X
O13	Connectability (wifi, cable, etc.)	X	X		X	X	X	
O14	Eco-design		X					X
O15	Economic		X					X
O16	Ergonomic				X			X
O17	Capability (platforms: pc, phone, mac, etc.)	X			X	X	X	
O18	Environment friendly					X		
O19	Respected norms					X		
O21	Usability (age interval)				X		X	
O22	Clear	X						
O23	Light	X						X
O24	Tactile	X						
Total		13	7	2	11	7	5	8
General Total:		21	11	23	29	15	14	11

14. Tools that support automatic scenario building and usage

Hsia and Yaung (Hsia et Yaung 1988) discuss about screen-based scenario generator (SBSG) an interactive tool for a system analyst or a customer to create, edit, compile, and execute the mock-up of a desired system without requiring any programming language. Scenarios are then described as the sequence of man-machine interactions that satisfy certain user objectives. This tool is based on scenario-based prototyping that uses scenarios to stimulate events that users would experience in performing tasks (which consists of the operations of a system).

Another tool is Rosson and Carroll's "scenario browser" (discussed in (J. Carroll 2000), pp.245)), which is a scenario-based object-oriented design tool. The tool coordinates multiple views of scenarios (task-centered, object-centered, class-centered, code-centered) that support the analysis process.

On the other hand, Yamazaki (Yamazaki et Hirano 2001) propose VSDL (Very High-Bit-Rate DSL) systems to share the video scenarios between distributed design groups. The idea is that the lead designer act as the user in front of the camera and the other design actors evaluate this video and add comments. Then, according to this comments lead user change the scenario. When all design actors agreed on the scenario, the final video recorded and stored.

Finally, Muller et al. (Muller et al. 1995) propose PICTIVE (Plastic Interface for Collaborative Technology Initiatives through Video Exploration) and CARD (Collaborative Analysis of Requirements and Design) techniques. In PICTIVE technique participants furnished with simple office materials and materials prepared by the developer, while as in CARD technique a set of cards in order to create scenarios.

15. Strength and Limitations of some of the discussed indicators

Strengths and limitations of the Spearman's rho indicator:

- This indicator gave us good insights about the convergence and divergence of the subjects, in terms of the importance given to the functional requirements.
- In this study, the subjects were asked to choose five most important functional requirements and rank them according to their importance. Then, we made the assumption that the other functions are ranked in the 6th order, to calculate Spearman's rho. For further experiments, it is better to ask them to rank all functions instead, to gather more relevant results.
- In this study, the groups were free to choose their user populations between family and workgroup, or focus on both of them. For further experiments, in order to eliminate the confusion, either we limit the groups with one user population, or ask them to complete one ranking table for each population.

Strengths and limitations of the 5W coding:

- The realization of a coding schema, which will be understood in the same way by different coders, is difficult. When we analysed deeply the cause of these disagreements between coders, we remarked that the coding process is very subjective that the coders interpret the same data differently. For example, one of the commonly significant ideas listed by the subjects to the question "What the product is for?" was "to input data". However, some of the subjects were formulated it as "to input data manually" and some of them formulated it as "input data automatically". Since, inputting data manually and inputting data automatically are not the same ideas, we formulated them as separated categories in coding schema: "input data manually" and "input data automatically". This level of detail in coding schema enhanced the truthfulness of the analysis, but augmented the complexity of the coding process. Because, when the subjects give more general answers like "input data" without indicating how, the coders couldn't decide, to which category that fits into. However, in the case that we make more general categories, the subjects who answer the same questions differently: "input data manually" and "input data automatically", will be accepted as given the same answer.

Similarly, in some cases the subjects are given really general answers that might cover all other categories. For example, for the same questions "what the product is for?", some subjects gave the answer "organize group planning". Thus, we added this category in the coding

schema. However, it was again confusing. Because, depending on the understanding of the coder, a subject, who listed the idea “synchronize different people’s calendar’ under that question, might be interpreted as given an answer which fits into “group planning” or not. Briefly, the creation of coding schema in that kind of analysis is problematic.

16. Some other deductions from the study

- **The design actors do not have a tendency to use methods during the meetings.**

Although, in Group A they were free to use the methods that they think useful (which was also written on the briefing), any group used a new method. One of the subjects (in Exp1 group A) indicated that he thought that they could use other methods generally used as a part of value engineering, but they did not take the liberty to use, because it was not a part of the protocol. In Exp 4 group B, subject 1 argued that it is also quite common in real design meetings. He claimed that if people were not asked to use a method, they wouldn't use it, even if they were informed about it. He fortified his argument by these words "if you run the same experiment with the same people tomorrow, if you don't ask them to use today's methods, they won't use, although the method is really useful".

- **The complexity of the available formalisation techniques of the requirements.** One important point came forward in experiment groups that they got lost in the questions of "what is a function?" and "what is a criteria?". Especially, Exp 2 group A was Even in the middle of the meeting, they were not sure if they have interpreted them correctly. We can see this hesitation between the 42nd and 43rd minutes of the meeting:

"Subject 4: We're about half way, guys. I don't think we're doing too badly.

Subject 1: Depends if we've interpreted function and criteria correctly."

Three subjects of Exp 2, they also commonly underlined the difficulty to understand the real meanings of the terms "function", "criteria" and "metric" tables, during the interview. Thus, we conducted a discussion session with the subjects few days after the experiment. It was not an obligation for the subjects to participate to that session; so that only interested subjects were presents. The aim of the discussion session was to understand the reason for what in Exp 2 they had more difficulty to have a common vision of that method within the group, compared to Exp 1. As a reminder, while Exp 1 conducted in France, Exp 2 was conducted in England. Some French and English engineering lecturers interested with the issue were also present during the discussion session. The session was audio taped. During the discussion session we realized that, the expertise level of the subjects with this method was different in Exp 1 and Exp 2. Because, in Exp 1 subjects have already used this method as a part of their engineering lectures, while as in Exp 2 it was the first time that they used it, because it was not a part of engineering program. On the one hand, this underlines the fact that design is a social process that the background, origin, etc. of the design actors affect the way they use the design artefacts. On the other hand,

for this project we can infer that, training sessions might be more effective than the training documents for ensuring the intelligibility of the methods.

The gap between the marketing and design group. We have also observed that subjects believe that there is a borderline between marketing and design group, and defining the requirement list is the job of the marketing staff. That is why, subjects kept telling that they have not that much expertise on how to elicit and formalize requirements. For example, one of the Subjects claimed that FCM table has to be transferred to the designers, once it is completed. Then the conversation follows like below:

“- Designers are not presents during the completion of the table?”

- No. They only get the completed table.

- What you mean by designer? You really mean designer or you use it as “concepteur” in French definition? (Note that, “concepteur “is used here in a broader sense to mean all design actors, who are integrated to the design process)

- Good question. Yes it is true, you also need designers to have an idea on functions, etc. Quite a bit from everyone then.”

On the subjects' mind the roles of marketers and designers were separated. However, when the interviewer kept asking questions, she changed her mind and affirmed that logically it could not be separated. Similarly, in Exp 3 the expert designers also mentioned many times the necessity to talk to marketers to get information about the user needs.

17. Ranking Lists of the Subjects

Exp 1- Group A	Subject 1		Subject 2		Subject 3		Subject 4	
	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight
F1.1	3	20	1	20	5	5	4	15
F1.2	3	20	1	20	1	35		
F2	4	10	2	25	4	10	5	10
F3			3	15	3	15	3	20
F4	5	10			2	35	2	25
F5								
F6								
F7	2	30						
F8								
F9	1	30	4	20			1	30
F10								
F11								
F12								
F13			5	20				
F14								
F15								

Exp 2- Group B	Subject 1		Subject 2		Subject 3		Subject 4	
	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight
F1	4	15	1	40	1	40		
F2	5	5	3	15	3	15	4	10
F3	2	25	4	15	2	30	2	30
F4	3	20			5	5	3	20
F5								
F6			5	10			5	10
F7	1	35	2	20	4	10	1	30

Exp 1- Group A	Subject 1		Subject 2		Subject 3		Subject 4	
	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight
F1.1			1	25	2	30	2	35
F1.2			2	25				
F1.3								
F1.4							4	10
F1.5	5	10						
F2			3	25	1	40	1	40
F3					5	5	3	10
F4	1	50	4	12.5				
F5					3	20	5	7
F6	4	10						
F7								
F8								
F9					4	5		
F10	3	10						
F11	2	20	5	12.5				

Exp 2- Group B	Subject 1		Subject 2		Subject 3		Subject 4	
	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight
F1	4	20	1	10	5	10	2	20
F2								
F3								
F4	2	20	3	50			3	20
F5	3	20	4	10				
F6	1	30	2	20	1	30	1	30
F7	5	10	5	10	2	20	2	20
F8					4	20	4	15
F9					3	20		
F10							5	15
F11								
F12								

Exp3- Group A	Subject 1		Subject 2		Subject 3		Subject 4	
	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight
F1	2	25	1	31	1	25	3	20
F2	1	30	3	29	4	15	2	20
F3	3	25	2	30	2	25	1	35
F4	4	12	5	5	5	15		
F5					3	20	4	15
F6								
F7								
F8								
F9	5	8	4	5			5	10

Exp3- Group B	Subject 1		Subject 2		Subject 3		Subject 4	
	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight
F1	3	15	4	15	1	25	2	20
F2			3	20				
F3	2	35					5	10
F4								
F5	1	35	2	25	2	25	4	20
F6			5	10	5	15		
F7			1	30	3	20		
F8							3	20
F9	4	8			4	15		
F10	5	7						
F11								
F12							1	30

Exp 4- Group B	Subject 1		Subject 2		Subject 3		Subject 4	
	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight	Ranking order	Relative weight
F1	2	30	1	15	2	5	1	30
F2	1	35	4	20	3	5	2	30
F3			2	30	5	5	3	20
F4	3	20	5	5	4	5	4	15
F5								
F6	4	10	3	30	1	80	5	5
F7	5	5						
F8								

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