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Persona logical thinking: improving requirements elicitation for multidisciplinary teams

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ABSTRACT

To be more successful, innovation projects need a multidisciplinary team to cross and challenge several knowledge fields and viewpoints. However, defining methods to be used by multidisciplinary design teams is not straightforward since a single method has to match different skills and personality types. Our main objective is to provide a new method suitable to such multidisciplinary teams. The goal of Study 1 is to highlight that designers' specialty (i.e. engineer or ergonomist) has an impact on methods' effectiveness. For that purpose, we selected two methods for requirement elicitation, one that is generally used by engineers (a subset of EPMcreate method based on logical structure) and one commonly used by ergonomists (the Persona method based on empathetic reasoning). These methods were tested by 10 ergonomists and 10 engineers during individual sessions. We subsequently developed a method called Persona Logical Thinking (PLT) based on the combination of the two previous methods. This new method was tested in Study 2, and compared to Persona method and to EPMcreate method during collective sessions involving four designers each (engineers, industrial designers and ergonomists). Nine design teams took part in the study with a total of 36 participants. Our results suggest that PLT method draws on the advantages of both logical and empathetic reasoning since it is as productive as POEPMcreate method and as relevant as Persona method. It may therefore be more appropriate for multidisciplinary design teams.

1. Introduction

The design process can be synthesised in four phases: requirements analysis, specification, detailed design and manufacturing (French, 1985; Pahl and Beitz 1996). Requirements include User needs, Product functions and Technical solutions (AFNOR 2011, 2013) which all contribute to refine the project objectives, to reduce iterations, to abandon functions that are too expensive and finally to achieve higher quality. Product acceptability on the market and user satisfaction are also higher following a good requirements analysis (Nielsen 1993; Damodaran 1996; Anastassova

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Table 1. User requirements methods in design and innovation project.

Collection of existing requirements	Identification of new requirements
QFD (Akao 1993; Bergquist and Abeysekera 1996)	Creativity (Michalko 1991; Alberti, Dejean, and Cayol 2007).
Kano model (Shen, Tan, and Xie 2000)	EPMcreate/POEPMcreate (Mich, Anesi, and Berry 2005; Sakhnini, Mich, and Berry 2012)
Functional analysis (Viola et al. 2012)	Persona (Blomquist and Arvola 2002; Bornet and Brangier 2015)
Benchmark (Camp 1995; Donthu, Hershberger, and Osmonbekov 2005)	Scenario (Carroll 1995; Chin, Rosson, and Carroll 1997)
Market research (Jiao and Chen 2006; Lendrevie, Lévy, and Lindon 2009)	StoryBoard (Madsen and Aiken 1993; Lenté, Berthelot, and Buisine 2014)
Conversational methods (Goguen and Linde 1993)	Lead-user (Von Hippel 1986; Lüthje and Herstatt 2004)
Observation/task analysis (Hackos and Redish 1998; Norimatsu and Pigem 2008)	Role playing (Buchenau and Fulton Suri 2000; Newell et al. 2006)
Card sorting (Rugg and McGeorge 1997)	Focus group (Caplan 1990; Frohlich, Lim, and Ahmed 2014).
Ethnographic approach (Blomberg, Burrell, and Guest 2002)	Diary keeping (Maguire and Bevan 2002)
Netnography (Kozinets 2002)	

2006; Rexfelt and Rosenblad 2006). Both the collection of existing requirements and the identification of new or unexpressed ones are important to include in the design process, but they are supported by slightly different methods (see Table 1). In innovation projects, the anticipation of future needs helps the design team imagine a stronger concept and maximise its success. This innovation strategy sometimes called 'need seeker' is recognised as the most efficient one, following the example of Apple, Procter & Gamble or Tesla (Jaruzelski, Staack, and Goehle 2014). However, need seeking is a difficult matter since users experience great difficulties expressing their needs in the future or projecting themselves into future uses, especially when the product of interest does not exist yet (Petiot and Yannou 2004; Brangier 2007; Nagard-Assayag and Manceau 2011). Design teams have to develop new methods to identify future needs for the end-users.

According to Aoussat (1990), the design team is usually multidisciplinary with experts coming from different scientific domains, such as engineering, industrial design, ergonomics or marketing. Each domain and each expert has his own skills (knowledge, point of view, tools and methods …) and it may sometimes prove difficult to share knowledge within the team (Caelen and Zreik 1995; Mital 1995; Darses and Falzon 1996). From the Personality types described by Jung ([1921] 1993), Briggs and Briggs-Myers (Myers, McCaulley, and Most 1985) elaborated a practical tool to identify personality types of individuals: the MBTI (Myers Briggs Type Indicator). MBTI is based on four dimensions, each with two opposite poles: Attitudes (Extraversion (E)/Introversion (I)), Perceiving Function (Sensing (S)/Intuition (N)), Judging Function (Thinking (T)/Feeling (F)) and

Lifestyle (Judging (J)/Perceiving (P)). The combination of these dimensions gives 16 personality types corresponding to the preferred individual poles. Keirsey and Bates (1984) simplified the 16 MBTI personality types into four important groups: 'Rationals' (NT), 'Idealists' (NF), 'Guardians' (SJ) and 'Artisans' (SP). The CAPT (Center for Applications of Psychological Type) investigated the correlations between personality types and occupations (Hammer and MacDaid 1992; Hammer 1993). The MBTI was used with thousands of workers in many fields and more than 250 professions were represented in over 20 job families. The results show for example that there are many rational profiles in engineers, corresponding to individuals with logical personalities, preferring to work with systems. On the opposite in idealist profiles (empathetic personalities), we find for example psychologists who prefer to work with people (we consider in our study that ergonomists belong to this category since ergonomists who participated in our research mainly come from Psychology curricula). Marketing experts and designers are found in rational and idealist profiles (Hammer and MacDaid 1992; Hammer 1993; Cauvin and Cailloux 1994; Myers and Kirby 1998). Other studies have focused on personality types with MBTI or HBDI (Herrmann Brain Dominance Instrument) in specific occupations like software engineers or industrial designers (Capretz 2003; Meneely and Portillo 2005). Some authors investigated the personality types of analysts to evaluate the level of creativity in the primary steps of New Product Development (Stevens, Burley, and Divine 1999). These authors analysed the degree of creativity of 69 NPD analysts using MBTI Creativity Index developed by Gough (1981). The evaluation focused on 267 NPD projects during 10 years. Some positive correlations were notably found between profits of projects and the level of analyst's creativity. Finally, the personality types of developers as assessed by the NEO Five-Factor Inventory were analysed together with the success of a software project (Acuña et al. 2015). The results show a correlation between developers' extraversion and software quality.

2. Research question

Given the impact of requirement analysis on the success of design projects and recent insight on the performance of need-seeker innovation strategy, we believe that it is necessary to promote methods supporting efficient requirement analysis and identification of new/future needs. To this end, the literature provides in particular two lines of recommendations: the first one highlights the importance of including multidisciplinary design teams, in order to account for diversity of viewpoints and stimulate creative thinking. The second recommendation considers that multidisciplinary designers may have different thinking styles and sometimes different personalities; hence requirement analysis methods should be adapted to all these differences. In this context, our goal is to address the general question of 'How to better include designers' diversity and increase requirement analysis effectiveness?'

In the present paper, we report on two studies contributing to answer this research question. The first study aims to test the assumption that existing methods are targeted to specific professional background. For this purpose, we selected two categories of designers (engineers and ergonomists) and two methods (EPMcreate and Personas). On the basis of Study 1 outcomes, we develop a new method and test it with multidisciplinary design teams in Study 2.

3. EPMcreate and Personas: two contrasted methods for requirement analysis

To test whether the effectiveness of the method used to generate user requirements depends on the professional background, we selected the following methods: on the one side, EPMcreate method was chosen because it relies particularly on a logical structure and seems appropriate to engineers' way of thinking; on the other side, Persona method was selected because it is commonly used by ergonomists and relies on empathetic thinking.

EPMcreate method was developed on a logical structure based on Boolean algebra: Conjunction (AND, denoted ∧), Disjunction (OR, denoted ∨) and Negation (NOT, denoted ¬) (Mich, Anesi, and Berry 2005; Sakhnini, Mich, and Berry 2012). With EPMcreate method, the design team generates requirements for two users (stakeholders or SH), with 16 view-point combinations: in Step 1, the team generates requirements which are common to user 1 and user 2 (SH1 ∧ SH2), in Step 2 they generate requirements for user 1 that do not concern user 2 (SH1 ∧ ¬SH2), etc. Sakhnini, Mich, and Berry (2012), developed a variant of EPMcreate named Power-Only EPMcreate (POEPMcreate), which is easier to implement and more efficient. In the requirements elicitation, they kept only the four major combinations (the most productive and non-redundant ones) from the 16 originals steps: Step 1 (SH1 ∧ SH2), Step 2 (SH1 ∧ ¬SH2), Step 4 (¬SH1 ∧ SH2) and Step 8 (¬SH1 ∧ ¬SH2). Figure 1 illustrates these combinations through Venn or Euler diagrams (Hill and Peterson 1968; Stenning and Oberlander 1995; Stapleton 2004; David 2008) for two (left) or four (right) users or stakeholders. EPMcreate and POEPMcreate are considered adapted to logical thinking because, first, their theoretical bases and representation formalism come from Boolean algebra. Secondly, because they emphasise a global approach to requirement analysis and to their Boolean relations and do not seek to distinguish between e.g. cognitive, behavioural and emotional needs in stakeholder experience.

Besides, in the Persona method, the information provided about users is supposed to create a sense of empathy to help the design team in refining the concept and the future product. Empathy requires both affective and cognitive responses (Davis 1983). In this respect, Personas aim to allow designers to feel and interpret action, thought and emotion of the users (Antle 2006; Bornet and Brangier 2013). The Persona method consists in creating fictional users profiles on the basis of data collected about real users regarding their needs, customs and expectations. A Persona includes a name, a face, a brief background (age, occupation, hobbies …) and all the information in connection with the product to
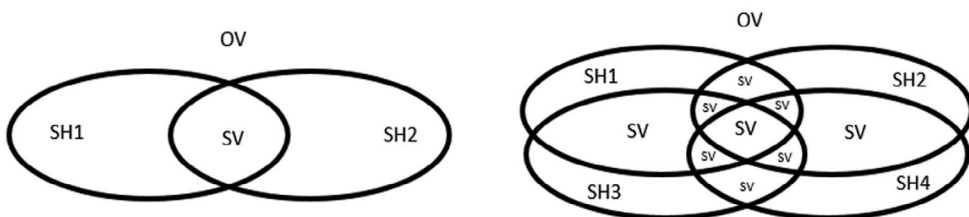

Figure 1. The geometric patterns showing the logical relationship between two stakeholders (SH1 and SH2) and four stakeholders (SH1, SH2, SH3 and SH4), OV represents other viewpoints and SV similar viewpoints.

develop. The representation of a Persona may take different forms: a digital storyboard, cardboard figures or a mere sheet of paper. Personal details like hobbies or personality may contribute to triggering a sense of empathy. For example, integrating photography with a smile can facilitate empathy and projection on the Persona (Antle 2006; Long 2009; Narme et al. 2010; Bornet and Brangier 2013). Persona can be used by the designers in every step of the design process, in order to always remind them of users' needs and expectations: they serve as sources of inspiration in the requirements elicitation and the creative phases, and suggest evaluation criteria to select design solutions (Pruitt and Adlin 2006).

Both these methods—EPMcreate and Personas—are effective in the early phases of the design process to help the designers understand user needs (Mich, Anesi, and Berry 2005; Pruitt and Adlin 2006; Dornberger and Suvelza 2012). Sakhnini, Mich, and Berry (2012) compared several methods to generate user requirements to improve a university website: their results show that POEPMcreate method led to more innovative and useful needs than EPMcreate method and Brainstorming. Astbrink and Kadous (2003) used Persona method associated to Scenario, to identify needs of people with disabilities for a wireless communication device. The authors observed that these methods enabled the designers to increase information and idea sharing throughout the project.

4. Study 1

This experiment was aimed to investigate whether requirement elicitation methods are adapted to diverse professional background. More specifically, Hypothesis H1 states that the logical EPMcreate method would be more suitable to engineers and the empathetic Persona method to ergonomists. To test this assumption, we evaluated the production of each designer during individual sessions. This study was carried out during an industrial project with a company whose goal was to develop a tablet dedicated to education and intended for pupils, students and teachers. We used this real-life goal of identifying future needs of these user categories in order to test our methodological hypotheses and to fuel the design process. The designers who participated in the experiment were selected from a multidisciplinary population of students.

4.1. Participants

Twenty participants were involved in this experiment (10 engineers and 10 ergonomists). All of them were final-year students in their respective curricula. There were 12 men (8 engineers, 4 ergonomists) and 8 women (2 engineers, 6 ergonomists) aged 21–32 years (24 years on average). Participants were not paid for their participation.

4.2. Material

On the basis of the aforementioned industrial project regarding the specification of a tablet for education, we selected two end-user profiles, a 'University Student' (Stakeholder 1 or SH1) and a 'Middle School Teacher' (SH2) for EPMcreate method. Since Persona method requires developing and personifying user profiles, the university student became 'Julie' (see Figure 2) and the middle school teacher 'Myriam'. Julie and Myriam's profiles were created on the basis of a survey filled out by twenty students and four teachers, about their

Julie

18 ans
Etudiante

Julie vient de passer son baccalauréat Littéraire et continue ses études à l'université Paris-Sorbonne en section « Lettre ». Peu habituée aux nouvelles technologies elle possède cependant une tablette tactile depuis l'an dernier pour ses études. Elle pense dorénavant que cet outil est vraiment utile et qu'elle aurait du mal à s'en passer.

PRESENTATION DE JULIE

Julie a 18 ans, elle habite en région Parisienne dans une résidence universitaire depuis le début de l'année. Ses parents n'ont jamais été très férus de technologie, préférant les activités de plein air (sport, ballade...) ou artistiques (peinture, littérature...). Julie n'a donc jamais vraiment baigné dans un univers technophile jusqu'à la rencontre avec son petit ami, Thomas, au lycée. C'est lui qui a commencé à lui parler des tablettes tactiles, elle se disait « curieuse mais réservée vis-à-vis de ce genre d'outils ». C'est lors de son précédent anniversaire que Thomas lui a offert une tablette tactile. « Cela correspondait au début de mes révisions pour l'épreuve de Français, j'avais pris comme sujet d'étude Molière ». Durant cette période Julie emmenait sa tablette partout avec elle « cela me permettait de libérer de la place dans mon sac à main chargé par les livres...l'application Kiosque m'a vraiment rendue service car j'ai pu récupérer de grands classiques comme Don Juan, Tartuffe ou encore Les Précieuses Ridicules ».

LES TABLETTES A LA FAC

A la fac son intérêt pour les tablettes n'a cessé de croître « j'ai beaucoup de présentations orales à préparer et cela m'évite de transporter mon ordinateur portable qui est 5 fois plus encombrant et qui a toujours besoin d'être rechargé ». Avec les outils de traitement de texte et les logiciels de présentation incorporés, c'est une sorte de « clé USB interactive ! ». Cependant elle ne cache pas qu'elle utilise toujours des feuilles et des stylos pour prendre ses cours « j'ai encore du mal à taper sur un clavier virtuel ». Dans son université ses professeurs mettent progressivement en place des systèmes de cours en lignes (pdf voire mp3), Julie peut donc les consulter n'importe où grâce à la couverture 3G, « de plus, lorsque l'on rencontre des problèmes on peut même chater avec les enseignants! ». Entre Internet et la mise en place de ces services, l'accès à l'information devient continue (24/24H et 7/7J) : « lorsque je rends visite à mes parents à la campagne, je peux continuer à travailler à distance tout en restant joignable ».

STORY-BOARD : Quelques moments dans le vie de Julie

Comme de nombreux étudiants, Julie travaille beaucoup chez elle, aussi elle essaye d'adapter son domicile pour que son travail soit efficace.

Pour se détendre Julie passe beaucoup de temps à l'extérieur, marche quotidienne pour aller à la fac et jogging hebdomadaire !

Figure 2. Julie the university student. We integrated some information about students' lifestyle, hobbies or attitude towards new technologies.

use of Information and Communication Technologies. We also gathered information from reports on the use of tablets in French school (e.g. Briswalter 2012). We emphasised important characteristics of end-users (goals, behaviours, preferences …) during the development of our Personas.

4.3. Procedure

Each participant belonging to a single profile (engineer or ergonomist; between-subject variable) used a method (EPMcreate or Persona; between-subject variable). Although requirements elicitation is usually carried out in groups, we decided to have the participants perform this activity individually to test Hypothesis 1. Comparing the performance of groups would indeed introduce a confounding factor in the analysis, because engineers and ergonomists may not have the same culture, training and working habits regarding collaboration.

For the EPMcreate method, we used a subset of questions, corresponding to the four optimal combinations of POEPMcreate (Sakhnini, Mich, and Berry 2012) enriched with two additional questions extracted from the original EPMcreate method (steps 3 and 5). The latter are introductory steps about each user's viewpoint (SH1, SH2) and correspond directly to the questions addressed in the Persona method. Hence, participants had to answer the following six questions in 24 min (4 min for each question):

Question 1 (SH1): What are the requirements of a university student?

Question 2 (SH2): What are the requirements of a middle school teacher?

Question 3(SH1 ∧ SH2): What are the requirements that are common to a university student and a middle school teacher?

Question 4 (SH1 ∧ ¬SH2): What are the requirements specific to a university student and that do not concern a middle school teacher?

Question 5 (¬SH1 ∧ SH2): What are the requirements specific to a middle school teacher and that do not concern a university student?

Question 6 (¬SH1 ∧ ¬SH2): What are the requirements which concern neither a university student, nor a middle school teacher?

Participants allocated to the Persona method were provided with the two Persona sheets and had to answer two questions in 24 min (12 min for each question):

Question 1: What are the requirements for Julie, the university student?

Question 2: What are the requirements for Myriam, the middle school teacher?

In both cases, the requirements were directly typed in a spreadsheet by the participants. Following this exercise, they were asked to fill in a simplified MBTI questionnaire with 36 items (Tieger, Barron, and Tieger 2007) in order to collect their personality profiles as a control variable. Finally, they were asked to comment on the method they had used (knowledge of the method, self-assessment, evaluation of the method …), and had to provide a global evaluation of the method on a 5-point Likert scale. The whole experiment lasted about 45 min for each participant.

4.4. Data collection and analysis

The effectiveness of the methods was evaluated by collecting the number of requirements generated, after suppression of within-subject duplicates (Osborn 1963; Torrance 1966). The personality profile was determined from four categories of affirmations representing

the four dimensions of the MBTI: Attitudes (Extraversion (E)/Introversion (I)), Perceiving Function (Sensing (S)/Intuition (N)), Judging Function (Thinking (T)/Feeling (F)) and Lifestyle (Judging (J)/Perceiving (P)). There are nine pairs of statements in each category and the participant has to choose the statement defining him best. For example in the category Attitude, the first pair of statements is: 'I'm a quiet person' (Introversion item) or 'I'm a dynamic person' (Extraversion item). In the present study, we were interested in the Judging Function, which corresponds to logical (Thinking) and empathetic (Feeling) profiles.

4.5. Results

The corpus composed of 547 requirements was analysed by means of t-tests. We first investigated whether the number of requirements generated with each method would vary according to the background of the designer: we expected that engineers would be more comfortable with the EPMcreate method and ergonomists with the Persona method. The results confirm that engineers were more effective with the EPMcreate than with the Persona method ($t(8) = 2,97$; $p = 0.018$; see Figure 3). However, the ergonomists' performance was equivalent with the two methods ($t(8) = 0.162$; $p = 0.876$).

We also investigated whether the number of requirements generated with each method varied according to the personality of the designer. We expected empathetic personalities to be more effective with the Persona method and logical personalities with EPMcreate method. The results of the simplified MBTI test shows that 6 engineers out of 10 had a logical rather than an empathetic profile and 8 ergonomists out of 10 also had a logical profile. The distribution of personality does not differ significantly between engineers and ergonomists (Khi^2(1)=0.952; $p = 0.329$). Regarding the number of requirements generated (see Figure 4), participants with a logical profile ($n = 14$) tended to be more efficient with the EPMcreate than with the Persona method ($t(12) = 1.998$; $p = 0.069$). Participants with an empathetic profile ($n = 6$) were not influenced by the method ($t(4) = 0.835$; $p = 0.451$).

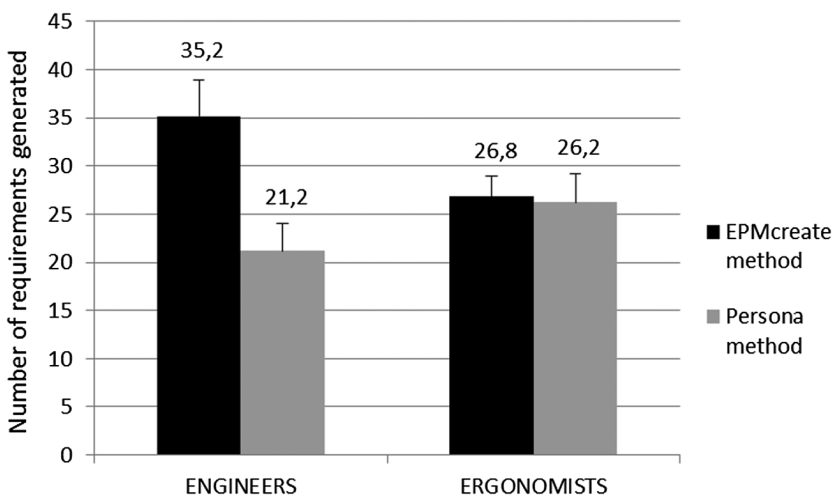The requirements were sorted into three categories:

Figure 3. Fluency with each method, as a function of the professional background.
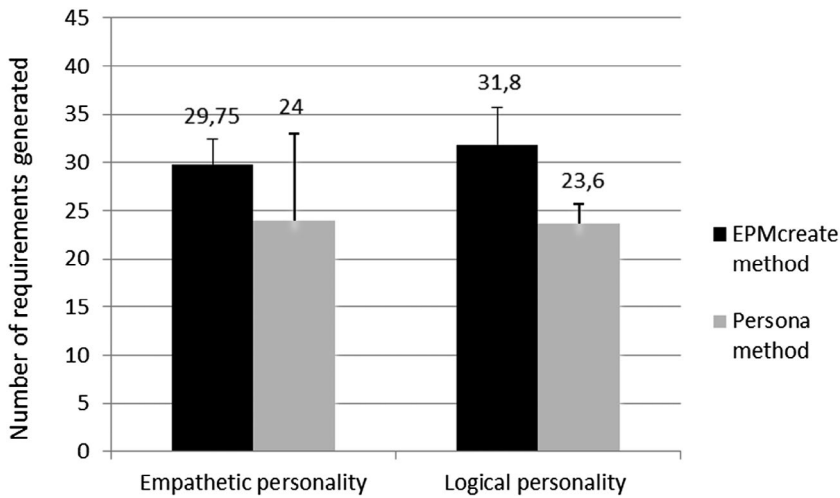
Figure 4. Number of requirements generated with Persona and EPMcreate methods, according to the personnality type.

- 'User's needs', which are user-centered requirements that were formulated by the participants without mentioning either the product of interest (i.e. a tablet computer) or the way to meet these needs. Examples of such requirements include: enable students to discuss with the teachers, support group work, read books, etc.
- 'Product functions', which are desired features of the future tablet, for example: be thin, be easy to use, have a powerful processor, etc.
- 'Technical solutions', which are existing components or applications that the future product should include, for example: a diary, games, a USB port, the school map, etc.

These categories correspond to three steps of the design process: needs analysis, functional specification and technical solutions (French 1985; Pahl and Beitz 1996; Robertson 2001; Maguire and Bevan 2002; des Mesnards 2011; AFNOR 2011, 2013). Depending on the nature of the design process (i.e. sequential, concurrent, iterative …), these steps can be processed as a chronological sequence or thought of simultaneously. Globally, User's needs represented 41% of the corpus, Product functions 52% and Technical solutions 7%. There was no significant effect of the method used on the production of any of these categories of requirements.

Finally, the satisfaction questionnaire revealed a perfect equality between the two methods ($m = 3.6/5$). The Persona method produced no difference related to the professional profile, but engineers assessed more positively EPMcreate method ($m = 4/5$) than ergonomists ($m = 3.2/5$). Ergonomists found it quite difficult to project themselves into potential uses with EPMcreate; a participant even proposed to integrate Persona profiles in this exercise/method. Many participants mentioned the lack of interaction during the exercise and said that requirements generation might have been more productive and original in group.

4.6. Discussion

Our first hypothesis was that the requirements elicitation method may be more or less adapted to different professional backgrounds and different personality types. We selected two methods to test this hypothesis: a variant of EPMcreate and the Persona method. We

assumed that EPMcreate, which is based on logical structure, would be more effective with engineers and logical profiles. In contrast, we hypothesised that Persona method, which is based on empathetic reasoning, would be more effective with ergonomists and empathetic profiles. Regarding professional background of our student population, the results indicate that engineers were more effective with EPMcreate method but ergonomists were as efficient with the two methods. Regarding the effect of the personality, we observed that logical profiles tended to be more effective with EPMcreate method whereas empathetic profiles showed no significant differences. Therefore, hypothesis H1 appears partially validated: some professional backgrounds (i.e. engineers) show more effectiveness with a method that is supposed to match their way of thinking, whereas the performance of other professional background (i.e. ergonomists) does not seem to be influenced by the method. Moreover, we expected that different professional backgrounds would be associated to different personality profiles, which was not true in our sample of participants. While traditionally in the MBTI test, logical profiles are more numerous in engineers and empathetic profiles in psychologists (Keirsey and Bates 1984; Capretz 2003), the distribution of profiles did not differ in our two groups of participants. Although ergonomists usually come from Psychology or Life science curricula, they may have a particular profile to be attracted by studies in ergonomics, and more generally by the domain of product design: they may share with their fellow engineers a logical approach predisposing them to work in this domain. We finally had a majority of logical profiles and certainly too small a sample of empathetic profiles (n = 6/20) to study their reasoning preferences. It should also be noted that empathetic profiles are known to be rare in the general population—10 to 15% of individuals (Keirsey and Bates 1984; Hammer and MacDaid 1992; Hammer 1993)—and that we used a simplified MBTI with 36 questions which is certainly not so accurate as the original inventory to capture personality profiles.

This study also had several methodological limitations: prior knowledge of the method may interfere on the results, since none of participants knew the EPMcreate method before the experiment while half of them knew the Persona method (three ergonomists and two engineers in the group that worked with the Persona method). In other words, the methods were not equivalent in terms of novelty or previous training, which may have affected the results. The student population is another limitation of the study because differences between novices and experts are known to impact e.g. idea production (Bonnardel and Marmèche 2004, 2005). However, conducting experimental research with students is also beneficial in many respects: it is a common means of increasing internal validity of empirical research and of predicting external validity (Höst, Regnell, and Wohlin 2000). Moreover, results can potentially be more impactful when obtained with students because they not only provide insights on design processes, but can also be directly used to improve educational settings and influence design processes of future professionals. Finally, a third limitation of this study was the individual use of the methods. These are normally used during team sessions to take advantage of cognitive stimulation and argumentative activities occurring in a group. For this reason, our protocol may have affected the number and nature of the requirements generated, in particular in its short timeframe (24 min instead of 1 to 2 h usually devoted to requirement elicitation sessions).

Study 2 addresses some of these limitations: first of all, in Study 2 we gathered designers with various training backgrounds (engineers, ergonomists and industrials designers) to conduct requirement elicitation sessions in groups for 60 min. Following Study 1 results, we also decided to disregard personality profiles since professional background is a more relevant variable in the workplace and we cannot reliably infer personality profiles from professional profiles. Therefore, in Study 2 the object of our analysis is the multidisciplinary

design team, whatever its members' personality profiles. To gain a more complete understanding of group production (Torrance 1966; Casakin and Kreitler 2005), we also decided to assess originality and usefulness of the items generated by the teams, in addition to the mere number of requirements produced (i.e. fluency). Finally, another goal of Study 2 was to investigate whether we could combine logical and empathetic reasoning in a single method: to this aim, we created Persona Logical Thinking method (PLT) on the basis of EPMcreate and Persona methods. Study 2 compares these three methods (EPMcreate, Persona and PLT) during group sessions involving four designers with different background, and analyses the corpus of requirements according to three variables (fluency, originality and usefulness).

5. Study 2

Study 1 suggested that the effectiveness of EPMcreate and Persona methods may be impacted by the training background of designers. Our goal is to provide a method suitable to multidisciplinary design teams, enabling each member to be comfortable with the type of reasoning whatever his/her background. To this end, we created a hybrid method based on the combination of EPMcreate and Persona methods: the PLT method. We assume that a collaborative method that combines different ways of thinking adapted to different skill profiles will be more effective because it will foster collaboration. The PLT method is considered to be equally logical than empathetic, because it uses Persona profiles to generate a sense of empathy, and questions related to logical relationship between requirements based on Boolean algebra. We hypothesise (H2) that this method allowing both logical and empathetic thinking will be more adapted to a multidisciplinary design team.

5.1. Participants

Thirty-six designers (19 engineers, 11 industrial designers, 6 ergonomists; 21 men and 15 women, aged 20–37 years, mean = 25 years old) participated in the experiment. They were all final-year or PhD students. None of them had participated in Study 1. They were distributed into nine multidisciplinary teams of four members and were not paid for their participation.

5.2. Material

As for the first experiment, the participants were asked to generate requirements for a tablet dedicated to education. They were introduced four user profiles: Julie-SH1 (university student) and Myriam-SH2 (middle school teacher) that were used in Study 1, to whom we added Tim-SH3 (middle school student) and Marc-SH4 (high school teacher). The inclusion of two additional stakeholders may increase the complexity of the methods, but this was necessary for the industrial project we aimed to contribute to. As in Study 1, the Persona sheets were composed on the basis of questionnaires filled out by pupils and teachers of a middle school and a high school.

5.3. Procedure

We assigned each team to one of three methods: EPMcreate, Persona and PLT (between-group factor). In all cases, requirements elicitation lasted 60 min.

In the EPMcreate method, the design teams had to answer 30 questions about requirements for the four user profiles (see Table 2):

Table 2. Combination of the 30 questions for the EPMcreate and PLT methods.

	SH1/Julie	SH2/Myriam	SH3/Tim	SH4/Marc	
SH1/Julie	SH1	SH1 ∧ SH2 SH1 ∧ ¬SH2 ¬SH1 ∧ ¬SH2	SH1 ∧ SH3 SH1 ∧ ¬SH3 ¬SH1 ∧ ¬SH3	SH1 ∧ SH4 SH1 ∧ ¬SH4 ¬SH1 ∧ ¬SH4	¬ SH1
SH2/Myriam	SH2 ∧ ¬SH1	SH2	SH2 ∧SH3 SH2 ∧ ¬SH3 ¬SH2 ∧ ¬SH3	SH2 ∧SH4 SH2 ∧ ¬SH4 ¬SH2 ∧ ¬SH4	¬ SH2
SH3/Tim	SH3 ∧ ¬SH1	SH3 ∧ ¬SH2	SH3	SH3 ∧ SH4 SH3 ∧ ¬SH4 ¬SH3 ∧ ¬SH4	¬ SH3
SH4/Marc	SH4 ∧ ¬SH1	SH4 ∧ ¬SH2	SH4 ∧ ¬SH3	SH4	¬ SH4
SH1 ∧ SH2 ∧ SH3 ∧ SH4					

Question 1 (SH1): What are the requirements of a university student?

…

Question 5 (SH1 ^ SH2): What are the requirements that are common to a university student and a middle school teacher?

…

Question 11 (SH1^ ¬SH2): What are the requirements specific to a university student and that do not concern a middle school teacher?

…

Question 23 (¬SH1 ^ ¬SH2): What are the requirements which concern neither a university student, nor a middle school teacher?

…

Question 29 (SH1 ^ SH2 ^SH3 ^ SH4): What are the requirements that are common to the four categories of users?

Question 30 (¬SH1 ^ ¬SH2 ^ ¬SH3 ^ ¬SH4): What are the requirements which concern none of the four categories of users?

In the Persona method, the design teams had to answer four questions about requirements for the four Personas:

Question 1: What are the requirements for Julie, the university student?

Question 2: What are the requirements for Myriam, the middle school teacher?

Question 3: What are the requirements for Tim, the middle school student?

Question 4: What are the requirements for Marc, the high school teacher?

Finally, in the PLT method the design team had to answer 30 questions about requirements for the four Personas (see Table 2):

Question 1 (Julie): What are the requirements of Julie the university student?

…

Question 5 (Julie ∧ Myriam): What are the requirements that are common to Julie the university student and Myriam the middle school teacher?

…

Question 11 (Julie ∧ ¬Myriam): What are the requirements specific to Julie the university student and that do not concern Myriam the middle school teacher?

…

Question 23 (¬Julie ∧ ¬Myriam): What are the requirements which concern neither Julie the university student, nor Myriam the middle school teacher?

…

Question 29 (Julie ∧ Myriam ∧ Tim ∧ Marc): What are the requirements that are common to the four users: Julie, Myriam, Tim and Marc?

Question 30 (¬Julie ∧ ¬Myriam ∧ ¬Tim ∧ ¬Marc): What are the requirements which concern none of the users?

In the PLT method, we expected to trigger both logical (by going through the 30 questions and logical combinations of user categories) and empathetic thinking (using the Persona sheets enabling to better appropriate users' customs and preferences). Therefore, we hypothesised that PLT method would be more efficient because it cumulates several viewpoints on user requirements and because the team would be more likely to take advantage of its diversity of viewpoints and reasoning modes.

Each session lasted 60 min, all requirements were expressed by speech and an experimenter was in charge of writing them on a flipchart. At the end of the experiment, the participants were asked to comment on the method they had used (knowledge of the method, self-assessment, evaluation of the method …).

5.4. Data collection and analysis

To assess the effectiveness of each method, we analysed three variables (Osborn 1963; Torrance 1966; Casakin and Kreitler 2005; Bonnardel, 2006):

- The Fluency (number of requirements generated without intra-group duplicates).
- The Originality (assessed by the uniqueness of items): requirements appearing only once in all groups' production are considered unique and therefore original.
- The Usefulness of each requirement, which was later rated by 45 end-users on a 5-point Likert scale: after the experiment, we created 8 online surveys with about 100 requirements each (which had been generated during the experiment) and circulated them to pupils and teachers of a high school for evaluating their usefulness.

5.5. Results

The whole corpus contained 1,116 requirements. After cleaning it from intra-group duplicates, we retained 945 requirements that were categorised as User's needs, Product functions and Technical solutions as in Study 1. In the present experiment, the corpus was composed of 37% of User's needs, 38% of Product functions and 25% of Technical solutions.

We then studied the effects of the three methods on the performance of requirements elicitation (see Figure 5). Because we analysed the data at the group instead of the participant level and had only three groups by method, we used non-parametric statistics and chose the median test to analyse the results. Regarding the Fluency variable, although the main effect of the method appeared non-significant ($p = 0.638$), PLT proved significantly more productive for the generation of 'Product Functions' ($p = 0.043$). The Originality variable showed the same pattern, with a non-significant main effect of the method ($p = 0.638$) but a significant advantage of PLT to generate original 'Product Functions' ($p = 0.043$). These results suggest that PLT improves productivity in the generation of 'Product Functions', including original functions (e.g. be recyclable, be resistant to chemical substances …) likely to drive the innovation process. The other pairwise comparisons showed no significant differences.

Regarding the Usefulness variable (see Figure 6), the data were analysed by means of an ANOVA and Fisher's LSD *post hoc* tests. The main effect of the method proved to be significant
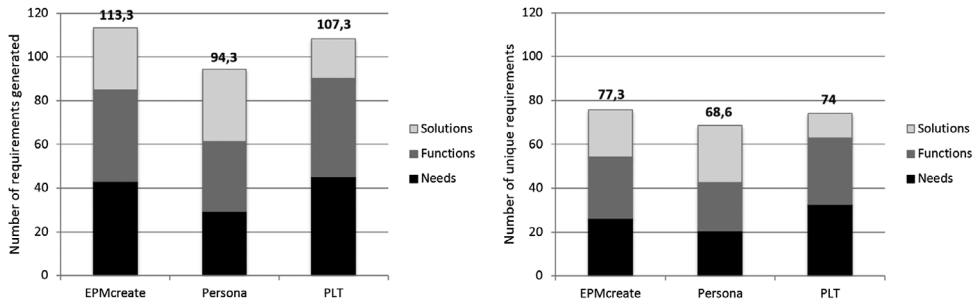

Figure 5. Results of fluency (left) and originality (right) variables as a function of the method.
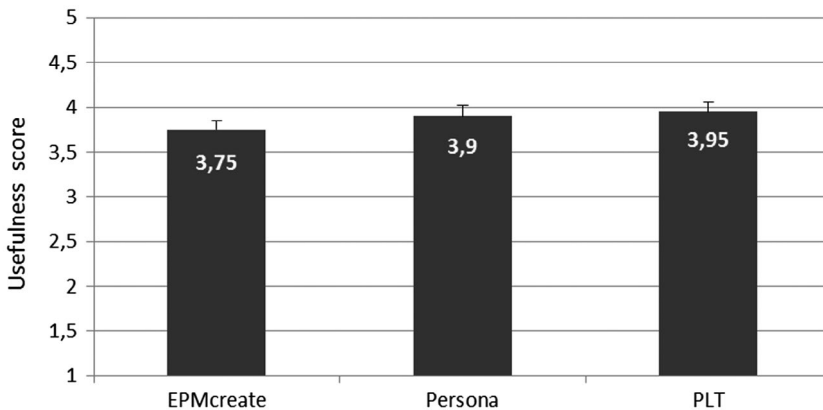

Figure 6. Usefulness of items as a function of the method (evaluated on a 5-point scale by 45 end-users).

(F (2/74) = 10.26; p < 0.001) with EPMcreate significantly lower rated than the others methods (p < 0.001) and no significant difference between PLT and Persona methods (p = 0.391).

6. Discussion

The results of Study 1 suggested that the effectiveness of some methods used in the design process may be impacted by the professional background of each designer: in particular, we observed that engineers' performance was higher with EPMcreate method, which is based on a logical structure. Study 2's main goal was to identify the most effective method for multidisciplinary design teams: in this respect, we assumed that a collaborative method combining different ways of thinking would be adapted to various professional profiles and more effective because it would foster collaboration. To test this hypothesis, we have developed a hybrid method based on Persona and EPMcreate methods: the PLT method. We therefore evaluated the effectiveness of this method and compared it to the original methods.

Our results indicate that PLT was as productive as the other methods, and is especially effective in the generation of Product functions, including original ones. Several interpretations can be put forward to understand this effect: the PLT method being partly based on Persona profiles, it naturally includes an upstream analysis of user needs that was conducted to create the Personas. User details contained in the Persona sheets may have directly triggered ideas for Product functions because in a sequential design reasoning approach, functional requirements come after user's needs (French 1985; Pahl and Beitz 1996; des Mesnards 2011; AFNOR 2011, 2013). Technical solutions may be the third step, and we speculate that in a longer session the number of technical solutions would increase. The distribution of requirements generated in Study 1 supports this interpretation, showing that in this shorter experiment Technical solutions represented only 7% of the corpus. The impact of the sequential design reasoning process may explain why 'Product functions' was the most discriminative category of requirements in the corpus. In this category, PLT benefitted both from the fluency stimulation provided by EPMcreate through logical thinking and from the sources of inspiration provided by the Persona profiles through empathetic thinking.

Moreover, the requirements generated with PLT are as relevant as those generated by the Persona method. Indeed Persona is a 'user-centered design' method enabling the design team to take end-users' point of view and identify useful requirements (Pruitt and Grudin 2003; Collards 2012). In sum, EPMcreate's main advantage may be its effectiveness with engineers (Study 1), Persona's main advantage may be its capacity to generate useful requirements (Study 2), and our results suggest that the combined PLT method may benefit from and cumulate these two advantages.

Regarding the comments expressed by the participants and the end of the session, we may mention that EPMcreate method was appreciated for the quick succession of questions that prevented participants from production blocking and helped them focus on essential requirements. About the Persona method, the participants mentioned that they experienced 'being users' and could 'deepen' requirements. All these arguments were also mentioned in participants' comments about PLT method. However, some designers found EPMcreate and PLT methods repetitive because of the large number of questions to address. To overcome this issue, we could examine only two users at a time and distribute the analysis of other user categories in several working sessions, as advocated by the authors of the method (Mich, Anesi, and Berry 2005). This may also facilitate logical combinations.

Future research may also extend the professional backgrounds investigated by including for example marketing experts, who also use the Persona method. Personality profiles should also be more accurately studied with an extended MBTI and a larger sample of designers, to better understand the relation between personality and professional background as well as the potential interaction between personality and the effectiveness of design methods.

Finally, as mentioned above, it would also be interesting to replicate the present study with seniors/experts designers in order to strengthen the external validity of the research and examine whether the expertise affects concept generation (Bonnardel and Marmèche 2004, 2005).

7. Conclusion

The collaboration between designers with various professional backgrounds (i.e. engineers, ergonomists, industrial designers, marketing experts) is essential for a project's success. The methods used throughout the design process may sometimes be compartmentalised: function analysis by the engineers, mood boards by the industrial designers, usability testing by the ergonomists, etc. However, some steps require that designers work together, like the generation of ideas in innovative projects, in particular to take advantage of the multidisciplinary nature of the design team. The results of our study open new perspectives in the development of multidisciplinary methods. It seems interesting to develop tools appropriate to the various characteristics of the design team (professional background, skills, personality types …) for different phases of the design process (requirements analysis, creative problem-solving, evaluation of mock-up …). We proposed in this paper a method to structure requirement analysis in the fuzzy front end of innovation projects. The requirements generated during our experiments were used by the company UNOWHY in the very early stages of the design process of a tablet dedicated to education (tablet computer SQOOL) and were further completed with field observations in schools, extensive surveys and co-design phases with end-users (students and teachers).

Currently, we try to investigate the possibility of using the PLT method with an interactive support in particular to improve the performance of the design team with a playful interface (Barré et al. 2014). Indeed, the creative potential of the design team can be improved with playful methods, but also with technological supports (VanGundy 2005; Buisine et al. 2012; Michinov 2012; Schmitt et al. 2012). We intend to create an interface on an interactive tabletop that integrates the presentation of the Personas and the logical combinations which come from EPMcreate method.

Disclosure statement

No potential conflict of interest was reported by the authors.

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