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Designing a Virtual Reality Software: What is the Real Contribution of End-users to the Requirements Prioritization?

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Abstract. This paper deals with the requirements prioritization which is a step, or an activity, of design process influencing the decisions for the development of software products. This step is often implemented by designers and uncommonly by users. The objective of this paper is consequently to characterize the implementation of requirements prioritization by end-users. For that, we examined literatures of requirements engineering and ergonomics and we conducted an empirical study with twenty end-users of a virtual reality software. In this study, we analyze the lists of prioritized functionalities and the functionalities evoked spontaneously by users. Results show that (1) the priority functionalities for users were not systematically implemented by designers, (2) the different priority levels depended on users' profiles, (3) the users who assigned 'important' and 'unimportant' priority levels evoked additional functionalities, and (4) the spontaneously evoked functionalities were mainly precisions of anticipated functionalities.

Keywords: prioritization, requirement, virtual reality, software design process.

1 Introduction

Requirements prioritization is a crucial activity in software design. Numerous research works deal with the study and the improvement of this part of the software process, for example in the field of requirements engineering and design ergonomics. These works are mainly focused on the description of several categories of prioritization methods: nominal scales, ordinal scales and ratio scales [1]. Comparison of these methods deals with the evaluation on usability and effectiveness by designers (e.g., [2]) or on their costs-benefits (e.g., [3]); the time needed to prioritize or the user satisfaction are some others criteria (e.g., [1]). These works have in common to only address the requirements priorization by designers, not by users.

These studies neither aimed to analyze the consequences of the use of prioritization methods on design decisions, nor to analyze how the results of prioritization by future

adfa, p. 1, 2011.

users could impact the design of the product or the software. Yet, it is now clear that user involvement in design is beneficial to provide a better balance between the designed artefact and the users' needs [4]. This is true in standard product design as much as in software design. This remains the same in a user-centered perspective, where the user is involved in the establishment of the needs and / or evaluation of the artefact (e.g., [5]), as in an approach called "participatory design" which considers the user as a co-designer involved in design decisions (e.g., [6]). This question underlines the issue of the involvement of several user profiles in the design process. While several studies have shown the interest to involve novice users and expert users in design (e.g., [7]), few empirical studies have sought to demonstrate the interest of involving end-users with different constraints, works and backgrounds, in the design process and even less in the requirements prioritization activity.

The main objective of this paper is to describe an empirical study on the involvement of different user profiles to the requirements prioritization. For that, we will firstly examine the real contribution of different profiles of end-users of a virtual reality (VR) software to the prioritization of functionalities. Because users can have different priorities according to their job and background, three profiles of users have been studied comparatively (stylists, engineers and marketers) relatively to the use of a nominal method of prioritization.

In the next section, we present a further review of the literature on requirements prioritization by different stakeholders, included end-users of a system, in the literatures of requirements engineering and ergonomics. Then we describe the methodology of our empirical study, and we expose our results which characterize the activity of prioritization of three users' profiles of a VR system and its consequences on the design choices.

2 Requirements Prioritization in Design by End-users

2.1 The "Requirement Prioritization" Concept according to Stakeholders

Requirement prioritization consists in assigning different priorities to the requirements in order to obtain a relative order between them [8] and finally to determine which requirements should be implemented first [9]. In that context, the requirements prioritization is a design activity [10]. This prioritization activity takes place in the selection stage which precedes the technical realization [11]. From this viewpoint, requirements prioritization is a crucial step during the software process.

In requirements engineering, the selection is made by the requirement engineer or the project manager or even the developer himself, based on four recommended criteria:

- the technical feasibility of each alternative [11];
- the degree of uncertainty and risk associated with each alternative [12];
- the evaluation of the costs and benefits of each alternative [13];
- the degree of convergence of different stakeholders in a design project for each alternative [11].

In this literature, the end user does not participate directly in the selection of alternatives, contrary to others disciplines where prioritization can be performed by end-users. In ergonomics, the selection of alternatives is done – at least partly – after the production phase of requirements and candidate specifications. Selected alternatives are used to produce a model which could evolve, that is, not directly the final software as in requirement engineering. In ergonomics as in requirement engineering, the stages of selection of the alternatives are prerequisites for achieving technical realization [14].

Both in the case of an iterative user-centred design [5] than in the case of participatory design [4] results obtained from the evaluation of the model are elements that will help to (re-)orient the design choices for a prototype. Indeed, users are most concerned to provide designers the necessary criteria to justify the new design choices in terms of destination of the artefact, but also in terms of profits and benefits for them. Moreover, the involvement of users is higher in a context of participatory design in which users, as co-designers, have the opportunity to make design decisions as well as designers. This suggests that decisions will take into account, at least in part, benefits for users, and not only designers' constraints as in requirement engineering. Loup-Escande demonstrated that the backers' requirements and users' needs, moderated by the designers' constraints, should be the specifications for the system design [15].

2.2 Prioritization Methods and Tools

There are many approaches, tools and methods recommended or used for prioritizing such as nominal scales, ordinal scales and ratio scales [2] which allow people to assign qualitative or quantitative values to requirements.

The 'Attributed Goal-Oriented Requirements Analysis' method (AGORA) [16] is an example of prioritization method, based on a graph used to decompose misunderstood goals until their understanding by each project' participants. In nominal scale methods, requirements are assigned to different priority groups. An example is the MoScoW method, which consists in grouping all requirements into four priority groups, that are requirements that the project (must / should / could / won't) have. All requirements listed in a category are of equal priority, which does not allow a finer prioritization. Ordinal scales methods produce an ordered list of requirements. For example, the simple ranking where the most important requirement is ranked 'one' and the least important is ranked 'n'. Simple sorting algorithms of sorting are also well suited to the requirements prioritization: for example, the "bubble sort" algorithm permits, by comparing the relative importance of requirements in pairs, to obtain a list of ordered requirements [17]. Another known method called Analytic Hierarchy Process asks users to compare all pairs of requirements [18]. Ratio scale methods provide relative difference between requirements (e.g. the hundred dollars method ask users to allocate a sum of money at each requirement). In addition to an ordered list of requirements, this method also helps to know the relative importance of each requirement in relation to other ones.

Users of these methods are generally specialists. Also, methods such as the 'bubble sort' remain difficult to master by people from the general public [1]. Different studies compared these methods (e.g., [1]): the metric used is the performance of the user (e.g., the number of decisions to make, time spent for the prioritization) or his satisfaction. Nevertheless, these studies are focused on the designers and elude the users of software which will contain implemented requirements.

2.3 Empirical Studies Focused on Prioritization Methods by End-users

Prioritization and selection of functionalities can in some cases be made in two stages. This approach is sometimes used in ergonomics and adopted in some design projects to develop innovative software. Requirements are firstly identified by the engineers with technical or cost constraints. Then, a panel of people representing the users is asked to prioritize the requirements according to their own criteria. This preliminary selection of the functionalities by the designers, prior to their prioritization by users, can result in the removal of functionalities with a potential high added value for users, because perceived as complex or costly for designers.

In other projects, requirements prioritization and selection can be performed by a group composed of designers and users. The integration of users in the selection of design choices helps to develop software in which functionalities and properties of the artefact will bring a real added value to users. We present two studies that include end users in requirements prioritization [19, 20]. These two studies did not explicitly identify the role of end users in the prioritization task: they were included in the group as well as designers and backers. But priority requirements (i.e. judged important) are different, according to the role or the status of the project stakeholders [8].

In the first study [20], participants (two users, three therapists, two technicians and a stylist) had to prioritize functionalities and select relevant functionalities to develop technical assistance for person with motor disability. They prioritized functional specifications by level of importance and of flexibility. This prioritization aimed at selecting the “relevant” features by performing a retrospective subjective assessment of them.

The second study aimed to clarify the problems and the needs of different stakeholders affected by repetitive strain injury in office activities [19]. To do this, focus groups involving ten participants were organized, composed of various profiles (e.g., users and managers of private/public companies, ergonomics experts …). The facilitator asked participants to list problems and needs related to the theme of ‘repetitive strain injury and physical organization of the post’, and other topics that they considered important to broach. Then, each focus group had to review the main requirements and prioritize them. Thus, participants were able to define by themselves the most important elements in terms of requirements, which avoided a personal interpretation by the facilitator of the previous discussions.

In both studies described above, the objective was not to analyze the activity of requirements prioritization by users specifically, but rather realized by a design group including users. The question of the impact of prioritization on design decisions is also not addressed. The limits of these previous empirical studies constitute the interest and motivation of the study described in this paper.

3 Methodology

To examine the requirements prioritization by different profiles of end-users and to evaluate the implications for the design, we analyzed the lists of functionalities prioritized on the basis of a questionnaire and the functionalities evoked spontaneously by users, in the context of a real software design project.

3.1 Context: the Project 3D Child

This exploratory study was conducted on an industrial project named ‘3D Child’. This project, led by a group of companies specialized in accessories for children, was divided into two parts. This paper covers the second sub-project in which we were involved. It was entitled ‘3D environments and places’: the aim was to design a virtual reality tool for three SMEs (A, B and C) to help them to evaluate their future products and to reduce time and cost of designing industrial products especially in the preliminary phases of design (i.e. prototypes). The company A, with three sites, is a furniture manufacturer with 1,050 employees. The company B, with a presence in fifteen countries, designs baby products and employs 4,700 employees. The company C is a cabinet maker, specializing in toys and employing nine cabinetmakers. This sub-project resulted in the development of a software dedicated to the presentation of interactive 3D scenes (children bedroom and car) composed of future products in which human characters - modelled in 3D could move (see Figure 1). This virtual reality tool is named ‘Appli-Viz’3D’ and is a software made for decision support in industrial design.

Fig. 1. Avatar in the “ bedroom” 3D scene (from Appli-viz’3D).

3.2 Participants

This study involved twenty participants, who are end-users of Appli-Viz’3D: eight engineers (three from company A and five form company B), eight stylists (four from company A, three from company B and one from company C) and four marketers (two from company A and two from company B). Most users of Appli-Viz'3D were also designers in their firms (engineers and stylists). Therefore, they were able to know or understand the constraints and technical potentialities of the software, compared with users who are not designers. This has certainly facilitated the elicitation of needs (Reich et al., 1996). Participants were 41.3 years old on average (S.D. = 7.8; min = 28; max = 60) and 20.1 years of work experience (S.D. = 8.6; min = 5; max = 37).

3.3 Data Collection: Questionnaire and Nominal Scale Method

The material used to collect data regarding the process of the functionalities selection and prioritization was a questionnaire. The questionnaire contained a list of functionalities of Appli-Viz'3D that users had to prioritize (Table 1 – white part). These functions were taken up from a previous demonstrator named 'Virtual Kid' - an online store that helped to launch the project '3D Child'. This questionnaire was elaborated by non-engineer designers, because we thought a priori that the designer-engineer would restrict at once the range of possibilities.

Participants had to prioritize these functionalities using marks from one to five (one = very important, two = important, three = moderately important, four = unimportant, five = useless). We chose the nominal method of prioritization for its ease of use that required no learning from users. We also asked participants to add their proposals of new features for the future tool.

The filling of the questionnaire was made following a presentation of the 3D Child project and a film showing the Virtual Kid application and the presentation of its functionalities. Virtual Kid movie should allow users to visualize the early functionalities on the list given in the questionnaire. In each company, we grouped the participants in the same room during the filing of the questionnaire.

3.4 Collected Data

Collected data are prioritized lists of functionalities, and eventually spontaneously evoked ones. These last functionalities can be prioritized or not. In the example shown in Table 1, spontaneously evoked functionalities (in gray) were not prioritized.

1	Positioning 3D avatars with ergonomic postures
2	Moving in the scene
3	Changing the arrangement of the objects
2	Seeing the scene with the perspective of a child (small size)
2	Defining the dimensions of the environment
5	Changing the color of the objects
5	Changing the texture of the objects
3	Changing the scenery
2	Seeing avatars moving in the scene
3	Changing the color of the walls
	Allowing the avatar to interact with objects (climbing up a ladder, opening a drawer)
	Integrating ambient object directly linked to the function of the project

Table 1. List of functionalities completed by a stylist (*priority levels* in *green, additional functionalities* in *grey*).

3.5 Analysis Method

To answer to our problematic, we analyze our data regarding:

- the relations between priority levels and functionalities;
- the relations between priority levels and proposals of additional functionalities;
- the characterization of the additional functionalities;
- the consideration of prioritization results by designers.

Statistical Analysis of the Priority Levels according to Functionalities.
The quantitative analysis is based on numbers counting. We counted the occurrences of the priority level given by participants for each functionality (e.g. 2 = important, see section 3.3.). We added these numbers for each of the three users' profiles, then for all profiles taken into account (engineer, stylist and marketer). The resulting data tables are contingency tables are crossing the variable 'functionality' with the variable 'priority level' for each profile. We defined the overall strength of the link between two variables (e.g., priority level) by calculating the Cramer's V2. The link is considered strong for V2 between 0.16 and 1.0, weak for V2 lower than 0.04 and intermediate between the two. Then we characterized the local strength of the link between two modalities of these two variables (e.g., very important …) by computing relative deviations (RD) between modalities. There is attraction (i.e., similarities between variables) when the RD is positive and repulsion (i.e., disparities between variables) when it is negative. The attraction is said to be remarkable for a RD greater than 0.25. For full theoretical demonstration, see [21]. RD are often used in exploratory studies since they allow a measurement of local associations within a set of data (e.g., [22]).

Relations between Priority Levels and the Presence versus the Absence of Additional Functionalities.
To analyze the relation between the priority levels associated with early functionalities and the proposal or the absence of additional functionalities, we identified the most frequently used priority level in each list (that is, the frequency of occurrence of this level was one point higher than the frequencies of other levels). When no level was distinguishable in terms of frequency, we removed the lists in question (three lists have been removed). A total of seventeen lists were analyzed. Then we counted the lists based on most frequently assigned levels and the presence vs. the absence of additional functionalities.

Analysis of the Proposals of Additional Functionalities.
We studied the content of spontaneously evoked functionalities to determine if they were really new or only precisions of the functionalities already listed. We define

new functionalities as they don't are a part of a functionality previously anticipated. A precision corresponds to a part or a detail of functionality already proposed in the list (e.g., "*integrating avatar of children and adults*" is a precision of "*positioning 3D avatars with ergonomic postures*" because it indicates that among the 3D models, adults and children should be integrated).

Then we counted the number of new functionalities and precisions to analyze the distribution in features spontaneously evoked. To avoid counting twice a same functionality, we analyzed qualitatively the functionalities added by users to identify those that were the same among all the lists. To do this, we established equivalences between expressions of functionalities that contained the same terms or synonyms (e.g., "*being able to manipulate and the functions of the products*" (evoked by an engineer) and "*permitting to use and to grasp objects*" (expressed by a marketer)).

Consideration of the Prioritizations by Designers.

To analyze the consideration of the users' prioritization by designers, we tried to identify, among the prioritized functionalities, those which were validated and implemented by the designers. For this, we mapped the priority levels associated with early functionalities and requirements that have actually been really implemented in the project.

4 Results

All the results of our study, corresponding to the analysis methods presented previously, are synthesized in the following part then discussed in the fifth section.

4.1 Priority Functionalities for Users not Systematically Implemented by Designers

The analysis of the relations between the two variables 'functionality' and 'priority level' shows an overall intermediate link (V2 = 0.07).

Table 2 summarizes the functionalities (left column), remarkable attractions (based on relative deviations) between priority levels and functionalities, and the state of the functionality at the end of the project, implemented or not implemented (grey). For one functionality (i.e., "*seeing the scene with the perspective of child (small size)*"), no remarkable attraction was observed (blank line in the table 2).

Functionalities	**Useless**	**Unimportant**	**Md. important**	**Important**	**Very important**
Positioning 3D avatars with ergonomic postures					X

Moving the scene					X
Changing the arrangement of the objects				X	
Changing the scenery			X	X	
Defining the dimension of the environment	X				
Changing the color of the walls	X	X	X		
Seeing the scene with the perspective of a child (small size)					
Changing the color of the objects	X		X		
Changing the texture of the objects	X		X		
Seeing avatars moving in the scene		X			

Table 2. Remarkable attractions between *functionalities* and *priority levels* (*X*), and state of the functionality at the end of the project (*grey* = not implemented).

This table underlines the absence of direct link between priorities associated by users and the state of the functionalities at the end of the project (implemented or not). For instance, the functionality "*positioning 3D avatars with ergonomic postures*", frequently associated with the 'very important' priority level (RD = 1.71) was not fully implemented. The reason given by the designer-engineer was related to technical constraints, particularly in terms of collisions between the avatar and the 3D model of the product. On the user side, some frustration has been felt to the delivery of the artefact. Conversely, the functionality "*changing the color of the walls*", which is characterized by strong attractions with priority levels 'moderately important' (RD = 0.84), 'unimportant' (RD = 0.50) and 'useless' (RD = 0.82) has been implemented. Finally, some features judged essentially 'moderately important' and 'useless' have not been implemented (e.g., "*changing the color of the objects*").

4.2 Different Priority Levels according to Users' Profiles

The analysis of the relations between the two variables 'functionality' and 'priority level' shows a strong overall association (V2 = 0.20) for the engineer profile, an intermediate link (V2 = 0.11) for the stylist profile and a strong overall link (V2 = 0.24) for the marketer profile.

We detail the priority levels associated with functionalities for each user profile in Table 3, based on analysis of relative deviations (i.e., remarkable attractions are represented by colors).

A first observation is that several priority levels may be associated with functionality within a same profile, as shown in Table 3: for example, the functionality "moving *the scene*" was associated with 'unimportant' and 'very important' levels by stylists.

A second observation is that the results suggest that the priority levels associated with a same feature may be common or specific depending on the profile of users (see Table 3). For example, priorities given for the functionality "*changing the texture of the objects*" are quite similar among profiles of users, contrary to priorities assigned to the functionality "*changing the color of the objects*".

Putting in perspective priority levels mostly assigned by each profile and functionalities really implemented suggests that there is no qualitative relation between the implementation of a functionality and the profile that judges it very important or important.

Functionalities	**Profile**	**Useless**	**Unimportant**	**Mod. important**	**Important**	**Very important**
Positioning 3D avatars with ergonomic postures	**E**					■
	S	■				■
	M					■
Moving the scene	**E**				■	■
	S		■			■
	M					■
Changing the arrangement of the objects	**E**					■
	S			■	■	
	M		■			■
Changing the scenery	**E**		■	■		
	S				■	
	M			■		
Defining the dimension of the environment	**E**	■	■			
	S		■			■
	M				■	
Changing the color of the walls	**E**	■	■	■		
	S			■	■	
	M		■	■		
Seeing the scene with the perspective of a child (small size)	**E**				■	
	S	■				■
	M			■		■
Changing the color of the objects	**E**	■	■			
	S			■		
	M					■
Changing the texture of the objects	**E**	■		■		
	S			■		
	M			■		
Seeing avatars moving in the scene	**E**			■		
	S		■		■	
	M		■			

Table 3. Remarkable attractions between priority levels associated to each functionality, according to the profile (*E* = Engineers, *S* = Stylists, *M* = Marketers).

4.3 The Users who Assigned 'Important' and 'Unimportant' Priority Levels Evoked Additional Functionalities

The majority of the lists contain proposals of additional functionalities (12/17, 71% - 3 lists have been removed, see part 3.5.2).

The analysis of the relations between the two variables 'presence or absence of proposal of additional functionalities' and 'priority level' shows an overall intermediate link (V2 = 0.13). The analysis of the relative deviations reveals that the lists of functionalities with the most of 'very important' priority levels don't contain any proposal for additional functionalities (RD = 0.36). For example, a stylist who assigned seven times the level 'very important' did not add any extra functionality. Similarly, the lists in which the priority level the most frequently assigned is 'moderately important' does not contain any functionality additions (RD = 0.36).

However, when the level 'important' is the most used in a list, this one also contains proposals for additional functionalities (RD = 0.42). Similarly, the level 'moderately important' is characterized by a strong attraction with the 'proposal of additional functionalities' (RD = 0.42).

When the level 'useless' is the most used in the lists, they may as well include proposals for additional functionalities, such as no proposals. For example, a stylist who assigned five times the mark 'five' (useless) did not propose additional functionalities. Conversely, an engineer proposed three additional functionalities whereas he mainly attributed the mark 'five' (i.e., useless) to the early functionalities.

4.4 The Spontaneously Evoked Functionalities Are Mainly Precisions of Anticipated Functionalities

Our data show that thirteen out of twenty participants evoked additional functionalities: seven are engineers, three are stylists and three are marketers.

The thirty-four additional functionalities evoked by users are distributed as follows: thirteen new functionalities (62%) and twenty-one precisions (38%). These thirty-four functionalities are the result of the sum of functionalities added in each list.

After grouping similar functionalities between two or more lists, we obtained finally fifteen additional functionalities: six new ones and nine precisions. The distribution of the six new functionalities and nine precisions in terms of common vs. specific to different user profiles is presented on the Figure 2.

Fig. 2. Distribution of new functionalities (*N*) and precisions (*P*) common or specific to each profile (*E* = Engineer, *S* = Stylist, *M* = Marketer).

As shown in Figure 2 concerning the six new functionalities (N), we observe that:

- One functionality is common to engineers, stylists and marketers (e.g. '*allowing the avatar to interact with objects (climbing up a ladder, opening a drawer)*', expressed by a designer);
- One functionality is common to stylists and marketers (e.g. '*making a short movie […]*', evoked by a designer);
- Two functionalities are specific to marketers (e.g. '*zooming on specific functions of the furniture during their use*');
- Two functionalities are specific to engineers (e.g. '*measuring spaces on the product*').

Concerning the nine precisions (P), we observe that:

- One functionality is common to stylists and engineers (e.g. '*positioning avatars of children and adults in a same scene […]*', evoked by a stylist; '*positioning the child/parent pair*', expressed by an engineer);
- Four functionalities are specific to engineers (e.g. '*defining standard environments: car trunk (Mini format), train door, bus, sidewalk, supermarket check-out*');
- Four functionalities are specific to stylists (e.g. '*integrating typical objects: baby's bottles, changing tables … in the scene to assess the function of the furniture*').

5 Discussion

The results show that the priority levels associated with the same functionalities can be common to several user profiles or different according to user profiles. We note that several priority levels can be assigned to one functionality by a same user profile. This confirms the need to develop consultations between several profiles of end users, followed by consultations between designers and end-users [23].

We observe that no marketer evaluated a functionality as useless, contrary to engineers and stylists who attributed the level 'useless' to some functionalities. One possible explanation is that engineers and stylists, who are more familiar with making design choices, are more at ease to say that a feature is useless for a given artefact. Marketers seem to prefer to assume that all the functionalities anticipated by the designers are useful at first sight, because none of them assigned the priority level 'useless' to the functionalities.

Our data highlight that a functionality considered as 'very important' for users might not be implemented as is. However, knowing that this functionality was 'very important' for users has driven designers to find a compromise leading to the implementation of a part of the functionality. Conversely, functionalities generally considered as 'unimportant' or 'useless', but considered as 'very important' by a profile of users in particular, may have been implemented. These findings suggest that the functionalities prioritized by the users are a source of information for designers. Theses ones try to take them into consideration: they care about the usefulness of the software. But user priorities are a set of information among others. That leads designers to implement functionalities they consider less costly (in financial and temporal terms), without leaving aside the prioritizations of the users which represent more a base of exchange than a list of functionalities to implement as they are. This confirms the interest to compose multidisciplinary team, including several profiles of end-users, in the early stages of the design process [24] and not only in the evaluation phases.

A last result of our study is that the majority of users evoked additional functionalities following the prioritization task, especially when users have attributed most frequently the levels 'important' or 'unimportant'. This evocation of post-prioritization requirements confirms what was supposed by [19] concerning the interest of involving users in the prioritization to clarify or propose new features, beyond their priorities. We suppose that a possible explanation is that providing users with some examples of functionalities enable users to have an initial understanding of the technological potential of the artefact. Prioritizing these examples allows them to imagine what could be the future artefact, and to evoke additional functionalities. These additional functionalities were mostly precisions of functionalities already anticipated and, to a lesser extent, entirely new functionalities. These last ones were common to several user profiles (i.e. either common to engineers, stylists and marketers or to stylists and marketers) or specific to a profile (in this case, marketers and engineers). The precisions were essentially specific to engineers and stylists.

6 Conclusions and Perspectives

The phase of requirements prioritization step is a key element of the software process as it will lead to the selection of functionalities to implement. The results presented above, and the ensuing discussion, allow us to make several recommendations to promote the design of artifacts with a real added value to the user. A first prerequisite is the integration of end users in the prioritization phase. In the field of collaborative engineering, previous studies have demonstrated that multidisciplinary design teams are beneficial to the design of products. The results of the study related in this paper allow us to go further by claiming that multidisciplinary teams of users are beneficial to the design of products which are in fact useful for them. Indeed, users have additional needs related on their job profile, which results in different priorities. This is particularly interesting in a context of "participatory" design, developed in Living Labs. Participatory design is based on a strong involvement of users in the expression of needs or the imagination of solutions, and on the fact that users must make decisions as well as designers. The prioritization phase is essential, because it allows future users to imagine new functionalities that were not proposed by the designers. However, giving users a first list of functionalities is crucial for them to imagine the future artifact to have food for thought. These prioritized lists are necessary for to allow designers to consider both their own constraints and user needs. This leads them to make compromises that benefit the real utility of the artifact to be designed.

A limitation of our study concerns the small project and the small sample size. That justifies the exploratory status of this study which allow us to obtain trends and not general conclusions about the differences between stakeholders. A second limit concerns the absence, in our data collection protocol, of elicitation interviews following the filling of the questionnaire. The realization of such interviews has not been possible because of constraints concerning the availability of the participants.

From this limit, a research perspective is to analyze the requirements prioritization by users adding to our original protocol elicitation interviews to know the reasons for assigning a priority level and how users perform this task. This would allow to identify finely subjective criteria justifying the levels assigned to each functionality. For example, we would then be able to explain why a user who gave the level 'unimportant' to functionality: is it because he imagined a very infrequent use or because he guessed he wouldn't need this functionality (but he did not dare to give the level 'useless')? We would also understand how each assignment was performed. Thus, we could know if people gave 'very important' level first or if they began with 'useless' functionalities. This would show that users know immediately what would useless or instead that users a priori know what they would need.

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