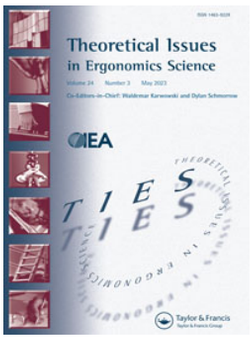

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Multi-user centered design: acceptance, user experience, user research and user testing

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ABSTRACT

In recent years, technologies have evolved towards social, universal and collaborative uses involving multiple users. However, methods and models from user centered design are focused on single-user design and do not take into account the impact of other users on intentions and behaviors to use the technology. The objective of this article is to provide paths of reflection on how to integrate a multi-user centered approach to existing user centered design methods and models. Each phase of user-centered design has been rethought to implement this new framework. Guidelines for moving from user experience to Multi-User eXperience (MUX) are provided. In the same way, we recommend adding a multi-user variable in the technology acceptance models to become the Multi-user Acceptance Model (MAM). User research and user testing have also been rethought to a multi-user reach and a multi-user testing. All these considerations are discussed, and lead to a proposal of a future Multi-user Centered Design (MCD) approach, specifically adapted to manage multi-user digital technology development projects. Finally, it is therefore necessary and important to direct research in the fields (acceptance, user experience, user research and user testing) to assist designers with the development of new methods of product design more respectful of social, environmental and collaborative values.

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Relevance to human factors/ergonomics theory

This article highlights areas for improvement in ergonomics theories and methods so that they better take into account the multi-user aspect of many current technologies.

1. Introduction

For the last two decades, technologies evolved towards social and collaborative uses integrating several users. Smartphones and tablets have become very common devices that are used mainly to serve multiple social purposes, mostly in developed countries (e.g. Rahmati and Zhong 2013; Yuen Fook et al. 2021). Simultaneously, social media has gradually become

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an immensely popular medium, omnipresent in the everyday life of a lot of people (Studen and Tiberius 2020) and the sharing economy activities based on digital platforms grow continuously (Hossain 2021). These technologies have been developed in almost all fields. In the world of work, home offices have been a trend for a long time and require adequate multi-user Information and Communication Technology (ICT; Hill, Ferris, and Märtinson 2003). With the same kind of technology needed, e-health and telehealth is growing with the objective to make care more accessible without geographical constraints and facilitate more regular monitoring with communication platforms making links between the patients and the health professionals (Dorsey and Topol 2016). The COVID-19 pandemic has substantially accelerated these trends. For instance, teachers have begun to use video-conferencing tools (e.g. Chatterjee and Chakraborty 2021; Abelsen et al. 2021), as well as office workers (Dewi and Muhid 2021). In the field of manufacturing, the emergence of the industry 4.0 is also described as notably based on collaborative networks (Dos Santos et al. 2020). Similarly in the video game field, socialization is one of the main motivations of the players (Bonny and Castaneda 2022), which is contributing to drive the market towards more multiplayer game productions.

Nowadays, virtual reality and augmented reality follow this trend of evolution of technologies and uses towards more interactivity and collaboration. These emerging immersive technologies raise many expectations about the improvement of collaboration (Muñoz-Saavedra, Miró-Amarante, and Domínguez-Morales 2020) thanks to richer interaction and better feeling of social presence. These developments lead to innovative modality of interactions between the users, such as asymmetric interactions (Jeong et al. 2019) or asynchronous collaboration (Morozov et al. 2013). The collaborative relevance of these immersive technologies is one of the main assumed strong points of the Metaverse, the internet of a future based on collaboration embodied in 3 D avatars (Hughes 2022).

Meanwhile, User Centered Design (UCD) has become a key field for taking the user into account in the design process of these technologies. The main models and methods of UCD allow to integrate the needs, constraints and expectations of firms and individuals in order to design more useful, usable and acceptable technologies. Nevertheless, these models and methods are not specialized to analyze multi-user technologies and the complex interaction between the users. Without an appropriate approach to the design of these multi-user digital devices or software that do not meet the expectations of future users, or even promote discrimination. In the end, as we mentioned, the best consideration of multi-user needs, constraints and expectations leads to useful, usable and acceptable tools. A better consideration of these elements would also allow technologies to evolve towards new innovations that are more respectful of humans, the environment and society. This maladjustment may concern any multi-user digital tool such as collaborative tools or communication tools (one to one as phone, or social media). It concerns also the multi-sided platforms that have the particularity to be multi-user tools for which the roles of each user can be different and interrelated (for instance one buyer and one seller interacting thanks to the platforms). In these cases, user experience acceptance and usefulness for one tester of the ICT could be related to the other users or future users, their characteristics and their capacity to meet his expectations. Nowadays, to the best of our knowledge, no study has focused on theorizing the multi-user technologies aspects probably because this problem is not yet clear and is only beginning to be referenced (e.g. Fleury et al. 2017; Bhattacharyya, Verma, and Sampath 2020). Therefore, the present article

provides paths of reflection on the integration of a multi-user approach in the main methods and models of UCD. To do this, we reviewed some of the main concepts and stages of UCD (user experience, technology acceptance models, user research and user testing) by integrating a multi-user variant in order to bring a new approach to User-Centered Design to become Multi-User Centered Design. At the end of each section, we discussed about perspectives and suggested future studies. Finally, we present a section on our vision of what multi-user design could be.

2. Multi-user eXperience (MUX)

User eXperience (UX) commonly evaluated in UCD projects, corresponds to a holistic perspective of product quality taking into account, as well as utilitarian characteristics, fun, pleasure and ludic value. The model of UX described by Hassenzahl (2004) is based on the idea that designers and users have representations of the product in terms of features, characters and consequences. The features are content, presentational style, functionality and interactional style of the product. These features are combined by a designer to obtain a particular intended product character. The characters summarize a product's attributes, as useful, amusing, stimulating, etc. During the interaction between the users and the product, people construct a personal view of the product characters, named 'apparent product character', which are pragmatic and hedonic attributes. There is no guarantee that the character intended by the designer is perceived by the user in the same way. For instance, a product intended to be enjoyable is not necessarily perceived that way. The human-machine interaction has certain emotional and behavioral consequences in relation to the product characters and the context of use. Pragmatic or hedonic attributes can be more or less a priority depending on the context. The UX model of Mahlke provides some supplementary details (Mahlke 2008). In its view, the way the human-machine interaction occurs depends on system properties, user characteristics and context parameters. From this interaction, an UX emerges, composed of perception of instrumental qualities (utility, usability, etc.), perception of non-instrumental qualities (aesthetic, symbolic and motivational aspects) and the emotional user reactions (subjective feeling, motor expression, physiology reactions, cognitive appraisals, behavioral tendencies) generated by the two previous components. The overall judgments concerning the system, choice between alternatives and usage behavior are mentioned as the consequences of UX. In ISO 9241-210210 (2019), UX is defined as the perceptions and reactions of a user that result from the actual and/or anticipated use of a system, product or service. It is specified that the perceptions and reactions include emotions, preferences, comfort or behavior before, during and after the use and that it is a consequence of the brand image, presentation, functionalities, performances, inner state of the user in relation with past experiences, skills and personality, as well as the context of use.

UX is a multicomponent psychological phenomenon which is usually measured by questionnaires. One of the most popular ones is the AttrakDiff (Hassenzahl, Burmester, and Koller 2003). This questionnaire consists of 28 items for which participants respond on a 7-point Likert scale. These items measure the following dimensions: pragmatic qualities (usefulness and usability, what will support the achievement of the objectives); hedonic qualities (the capacity of the product to give pleasure to the user); identification (ability to

provide him popularity, to connect him to others); stimulation (the ability of the system to stimulate the user, to give him a sense of control); attractiveness (the combination of pragmatic and hedonic qualities to arrive at an overall appreciation). meCUE is a component model of UX and a questionnaire based on 30 items aims to measure the main constructs of UX (Lallemand and Koenig 2017). Four main dimensions are measures: product perceptions (usefulness, usability, visual aesthetics, status and commitment), emotions (positive and negative emotions), usage consequences (product loyalty and intention to use) and overall judgment. The User Experience Questionnaire (UEQ) is a widely used tool to measure UX with 26 items (Schrepp, Thomaschewski, and Hinderks 2017). Six dimensions are considered: attractiveness (attractive, enjoyable, pleasing), perspicuity (easy to understand, to learn), efficiency (fast interaction, no unnecessary effort), dependability (predictability, confidence), stimulation (excitation and motivation to use the product, enjoyability) and novelty (innovation, creativity).

We noted that the main models and definitions do not explicitly mention the role of the other users in UX. Even in the questionnaires, some versions have been made to better take into account the context (Lallemand and Koenig 2020), or to fit with a specific technology such as virtual reality (Tcha-Tokey et al. 2018), but to our knowledge, none of them includes any dimension concerning the multi-user aspect of the technology. Certainly, it can be argued that traditional UX measures indirectly capture the results of social interactions. For example, interactions lacking in friendliness may result in low hedonic qualities in UX questionnaires. However, when UX is assessed, it is not to know whether it is high or low, but to make design decisions based on the results. To do this, it is essential that the measurements can be used to distinguish accurately the drivers of the UX.

Nevertheless, there are many examples of situations in which UX is intrinsically related to the multi-user aspects and the way interaction with the other users is going on. When someone plays a multiplayer online game, it seems obvious that the experience can be considerably determined by the dynamic of interaction with the other players during a collaborative quest. Players of real time strategy games tend to prefer to have as enemy humans rather than artificial intelligence (Madan 2020), which highlights the crucial role of multi-user aspects on the experience. Another conclusive example is the evaluation of UX related to a carpooling application. For users who are researching cars to transport them, the experience can be driven by the adequacy of the times of the travel which correspond more or less to their demands and constraints, and also by the trust in the drivers who suggest the trip (trust on their punctuality, their safety behavior when driving, their kindness, etc.).

The development of a Multi-User eXperience (MUX) model and questionnaire would allow to clarify and capture the data about these crucial aspects of UX in multi-usage. Future research would be focused on standardization of new questionnaires measuring MUX. Four types of measures seem to be relevant to bring UX to MUX:

- *Social presence*, which is the feeling of being with the person. Social presence can be improved on a ICT by using pictures or streaming video of people (Borup, West, and Graham 2012) or making voices hearable (Lee and Nass 2005).

- *Agreeableness of the human-human interaction*, that is related to friendliness and positive relationship. Maybe friendliness can be optimized using some specific modality of, communication such as forum or chat.
- *Adequacy to the needs*, the profiles of the other users are relevant for what a given user has to do with them. For instance, if a given user has something to sell, he.she needs someone who is looking to buy the same thing. Improving this variable can be based on community management and segmented marketing.
- *Adequacy to the expectations*, for example, in a multiplayer game, a user may want to face opponents at my level, or with a car pooling application, a user may prefer to select a driver with a comfortable car. This can be facilitated by using ranking systems or by making people share precise information.

3. Multi-user acceptance model (MAM)

Technological acceptance is an important dimension to consider when designing ICT to ensure that it will be used. Acceptance can be related to UX dimensions including perceived usability or enjoyment, but it can also be determined by other factors, such as perceived usefulness or other variables relating to user expectations. Acceptance is also a dimension that defines whether a product is used and will be adopted in the future, whereas UX is not concerned with future use intentions. In the same way as UX, acceptance is also impacted by inter-user collaboration and present models are not adapted to this evolution. Indeed, several models based on users' attitudes and perceptions of technologies aim to predict the intentions of use. The approach centered on social acceptance was historically developed by the theory of diffusion of innovations (Rogers 1983) based on users' perceptions. Nevertheless, this global theory does not include individual parameters. This is followed by a series of models including psychological processes based on satisfaction of use and intentions to use the technologies. The Theory of Reasoned Action (TRA, Fishbein and Ajzen 1975) describes how the behavior of individuals is influenced by their intentions to behave, which are themselves influenced by their behaviors and by subjective norms. This model was taken up to become the Theory of Planned Behavior (TPB - Ajzen 1985, 1991) by including perceived behavioral control, i.e. the user's skills, resources and opportunities. The first version of the Technology Acceptance Model (TAM - Davis 1989) is based on these two previous models. The author argues that the intentions to use a technology depend on the attitude toward using it which is conditioned by perceived usefulness and perceived ease of use. The development of the TAM has led to the emergence of models based on the same principle, i.e. to explain the intentions of use of technologies through different variables, mostly related to the perceptions of users (e.g. Venkatesh and Davis 2000; Venkatesh and Bala 2008). Based on all the previous models, the Unified Theory of Acceptance and Use of Technology (UTAUT - (Venkatesh et al. 2003; Venkatesh, Thong, and Xu 2012) includes main variables to predict the intention to use a technology (performance expectancy, effort expectancy, social influence and facilitating conditions) and moderator variables (age, gender, experience, voluntariness of use).

All these models can be used with different technologies (e.g. Amoako-Gyampah 2007; Choi and Ji 2015), different contexts (Brown et al. 2002; Y.-C. Huang, Hood, et al. 2013) and different users' profiles (Elias, Smith, and Barney 2012; Venkatesh and Morris 2000;

Eckhardt, Laumer, and Weitzel 2009; W.-H. D. Huang, Hood, et al. 2013) but remain focused on a single-user even if the technology is a collaborative platform (e.g. Bhattacharyya, Verma, and Sampath 2020; Fleury et al. 2017). For instance, in the study of Fleury et al. (2017) about the acceptance of carsharing platform, the authors used the UTAUT. Carsharing in organization involves sharing the same vehicles with colleagues, rather than, for example, having a vehicle allocated to one people. It is therefore likely that some of the barriers to acceptance may be related to fears that other users may dirty the vehicle, or return it late. Because the authors used the UTAUT, which does not take this multi-user dimension into account, they may have missed some determinants of carsharing acceptance.

In the above-mentioned models, only social influence (from UTAUT) refers to a notion of collective. Social influence is based on social identity (Tajfel et al. 1971) with the belief that the feeling of belonging to the group can push the individual to act according to the group's norms. In the context of acceptance models, social influence refers to 'the degree to which an individual perceives that important others believe he or she should use the new system' (Venkatesh et al. 2003, p. 451). For the last 20 years, social influence has been the most discussed variable because it is the most complex to measure (e.g. Eckhardt, Laumer, and Weitzel 2009). Several researchers working in the area of information technology usage suggest that subjective norms should be multidimensional (e.g. Davis 1989; Eckhardt, Laumer, and Weitzel 2009; Ajzen 1991). Several researchers have attempted to make improvements to this dimension. For instance, Srite and Karahanna (2006) suggested integrating new moderating variables 'individualism/collectivism' as 'national cultural values'. Culture is a collective phenomenon and, thus, irreducible to the individual level of analysis. 'Individualism/collectivism' refers to 'the degree to which the individual emphasizes his/her own needs as opposed to the group needs and prefers to act as an individual rather than as a member of a group' (Srite and Karahanna 2006, p.682). Nevertheless, this variable does not take into account the use of another person or a group of people on the same technology. Eckhardt, Laumer, and Weitzel (2009) questioned the UTAUT items on social influence. They considered that the term (included in the official definition above) 'important others' is too broad. Kim, Jahng, and Lee (2007) suggested focusing on the reference group and differentiated explicit (i.e. real use of the technology) and implicit (i.e. suggestion to use the technology) social influence as two distinct variables. Eckhardt, Laumer, and Weitzel (2009) determined the social influence depending on organizational context i.e. the referent groups (colleagues in the same department, superiors, other departments, customers) on adopters and non-adopters of a distinct technology in the recruiting department of firms. Cheung and Vogel (2013) are in line with these principles but consider each reference group as a separate variable of the UTAUT related to each user role in a learning platform (peer groups, external media and the lecturer). Several researchers suggested extensions of the UTAUT by integrating new variables: empathy (Phaosathianphan and Leelasantitham 2019), trust and perceived risk (e.g. Ben Arfi et al. 2021), perceived compatibility (Huseynov and Özkan Yıldırım 2019), perceived credibility and social norm (Palau-Saumell et al. 2019).

Despite the proposals made to integrate the importance of other users to improve social influence, these models do not take into account the influence of interactions with other users on intentions to use the technology. However, the intention of use of collaborative platforms for a given user could be impacted by his/her expectations regarding the characteristics of other users. For instance, in the field of e-health, Andersen, Rasmussen, and Frøkjaer (2017) demonstrate through their data collected between therapists and patients

the importance of collaboration on patient motivation. This should not be called self-monitoring but co-monitoring (Chaniaud 2020). For this reason, we recommend the development of the Multi-user Acceptance Model (MAM) which must be based on standardized validation on the new dimensions. This model could add a multi-user dimension including the representation of other perceived users. For instance, when using a carpooling platform, one expects the other user to be punctual and a good driver. In the same way, one expects his doctor or patient using a telemedicine platform to know how to use computer tools. Conversely, one should avoid collaborative social networking platforms or private exchange platforms that have users who are not friendly or caring. The intentions of use are probably related to the quality of interactions between users and adequate user representation in relation to what the technology allows to do. Expectations to other users should therefore be measured in terms of suitability (skills, particular quality, desires, etc) and relational aspects (friendly, distant, professional, non-intrusive, etc) consistent with the designed tool. Statistical analysis would determine if these aspects have to be considered as sub dimensions of the existing dimensions (perceived usefulness of the product, hedonic quality, etc) or as new dimensions.

4. Multi-user research

In a UCD project, the first step is to conduct user research. It consists in collecting information about the future users needs, habits, context, constraints and demands. This step is composed of two types of methods, primary research and secondary research. Ironically, secondary research is usually carried out first, since it is the consultation of documents bringing information about the future users who are the targets of the project. Documents can be for instance scientific research papers, marketing studies, opinion polls, technical reports, but also forums used by the target users. It is called secondary research because data is collected by other people. For now, it may be difficult to find some documents which would provide useful information concerning the multi-user aspects of a given future product. However, in a few years, it will be possible to find more resources if surveys about ICT are published using MAM or MUX.

Primary research corresponds to the methods for directly collecting data from the target users. This can be done for example by ethnographic research (Rosenthal and Capper 2006) or interviews (Wilson 2013). In a multi-user research approach, the ethnographic research or the direct field observation must take particularly into account the interaction between the future users of the solution. This can be inspired by a collective task analysis method, for example described by Pinelle, Gutwin, and Greenberg (2003) which records the types of communication (oral, written, gestural), but also non-communication interactions (for instance someone giving an object to someone else). This approach could lead to a mapping of interaction really useful to begin the design of a multi-user product. The interview, usually carried out in user research, must explore the future users expectations regarding the users community. There can be functional expectations (for example punctual car poolers on carpooling application or a trustworthy health professional on telehealth application), but also social and affective expectations (friendliness of a community on a social media or online game for example).

The main specificity of multi-user research is the need to conduct systemic needs and constraints analysis by crossing demands of the different users' roles. It is necessary to identify the divergences and convergences between demands of each user's role. Convergences should lead to functionality or characteristic of the product which will have to meet the demands that converge. Convergence can be complementarity, for instance between someone who is looking for a specific object to buy, and someone else who wants to sell this object. It can also be compatible, as two categories of users who expect friendliness in the interactions. Divergence is when there is a mismatch between the demands of the different user's roles. These mismatches require adapting the product characteristics to improve the future multi-user satisfaction. For example, some users of carpooling services expect conviviality during their travels whereas others do not want to talk. On online video games, some players can take the competitive aspect of the game seriously, and others can expect more friendliness. In these two examples, the risk is to have a lot of bad multi-user experiences due to these divergences. One solution can be to give some setting options in order to match the users with convergent demands. Systemic demand analysis could be conducted based on individual interviews followed by focus groups for example. Specific methods for this have to be the object of future research.

Overall, the primary user research methods allow to collect inputs from the future users, required to create persona or user journeys, but they have to be adapted when the product is multi-user:

- Persona of a multi-user product should include the expectations (functional, social or affective) concerning the community. It should also be connected with other personas corresponding to other roles, composing *clusters of personas*.
- User journey becomes *multi-user journey*, which should also emphasize the interaction with the other users to make clear the issues related to these interactions.

5. Multi-user testing

To find usability problems in the product being designed, the most common method is user testing. During user testing, users (or potential future users) are invited to do typical tasks with the product (Dumas, Dumas, and Redish 1999). During user testing, behaviors are observed and questionnaires are used as usability indicators (Bastien 2010), to identify specific usability problems, but also UX and acceptance are usually questioned. User testing can be used at any step of the design process, even with mockup and prototype, but also on finished products.

To face the specificities of contexts and the constraints of the different phases of the design projects, variations of user testing methods have been designed. Remote user testing is generally used when a lot of participants are needed, guerilla test to obtain very quickly some specific feedback, Rapid Iterative Testing and Evaluation is used near the end of the design project to make efficiently the last adjustments, A/B testing to compare to versions of an interface, test in laboratory to maximize the internal validity, test in situ to maximize external validity, or even wizard of Oz to evaluate a technically complex functionality without having to develop it.

Nutsi and Koch (2015) identified that the relevant design choices are very different when working on an interactive wall display for a single-user or the same wall for collaborative use. For instance, the interactive wall for a single user can display a localized menu (for example on the bottom bar) and use sound feedback when something happens. The multi-user multi-touch version of it must conversely avoid audio feedback which would disturb the other users, and requires a user workspace with accessible menu for each user simultaneously. This example emphasizes that the same technology, as the usage becomes collective, has to be designed very differently. If a user test had been conducted by only one participant on this technology, the conclusions could have been counterproductive.

Some recommendations can be done to improve multi-user evaluation of a digital product. The tests in situ are carried out in a real context. Therefore, a multi-user ICT which is tested in situ should be tested with the multi-user aspect really working. The main improvement that can be added in this type of test for multi-user systems is to measure MUX, MAM and social behaviors (speaking, writing messages, etc). Lab multi-user testing could be a user testing with several participants at the same time. They can be collocated or not, and synchronous or not, depending on the objective of the ICT. In some cases, it would be more relevant to simulate the main hypothesis concerning the behaviors or the other users. For instance, if a participant tests a car pooling application, the experimenter/designer can build test scenarios to confront the participant to different types of travel proposal (more or less adequate to the task), and with different types of profiles (men or women, various cars, etc). A last solution for the lab multi-user testing is to carry out a sort of innovative Wizard of Oz, in which peers have to play the role of other users and to voluntarily manifest specific behaviors to analyze the participant reactions. To conduct user centered evaluation of a multi-user collaborative augmented reality application for the building sector, Garbett, Hartley, and Heesom (2021) carried out a focus group with people of different professions (civil engineers, construction managers, architects, architects technologists). In this case, professions correspond to different roles with the application, in the sense that each of them will have a specific and complementary usage of the tool. Focus group bringing together all the roles appears to be a relevant way to meet the future users needs.

6. Toward a multi-user centered design (MCD)

The objective of the present paper is to provide some paths of reflection regarding the necessary adaptation of the main methods and concepts in UCD. More and more, multi-user digital technologies require a better analysis of the social aspects of ICT. Several recommendations are proposed above, concerning user research, user experience, acceptance and user testing. All these recommendations together lead to imagine what could be a future evolution of User-Centered Design (UCD).

UCD is a category of design methods mainly used for interactive systems, although it can be used for other types of products. The specificity of this approach is to be centered on the needs and requirements of the users to make the products usable and useful. The standard ISO 9241-210210 (2019) describes UCD as mean to improve the quality of a system by increasing the productivity of users and the operational efficiency of organizations; facilitating the understanding and use (reduction of training and support costs); increasing usability (effectiveness, efficiency and satisfaction); increasing accessibility; improving user experience; reducing

discomfort and stress; providing a competitive advantage (brand image improvement for example); contributing towards sustainability objectives. To achieve these goals, the design process has to respect the following principles: to be based upon an explicit understanding of users, tasks, resources and environment; to involve the users throughout design and development; to be driven and refined by user-centered evaluation; to be iterative; to address the whole user experience; to be carried out by a team including multidisciplinary skills and perspectives.

This iterative process can be divided into three main steps: User research, production and design solution, and evaluation (Figure 1). Several dimensions should be added at each stage to turn the User Centered Design (UCD) into the Multi-User Centered Design (MCD).

Firstly, the User research stage includes two activities: understanding and specifying the context of use and the user's requirements (ISO 9241-210210, 2019). The standard ISO 9241-210210 (2019) mentions that the approach has to take into account all the stakeholders and not only the users. For instance, the designers have to pay attention to the service technicians who will have to repair the product. It also evokes the diversity of profiles of users that sometimes need to be considered. For example, aged users and younger users may have some differences in their constraints, demands and skills. Nevertheless, as mentioned above, User research does not specifically emphasize the social needs and requirements of the users. The analysis stage should become a multi-user research phase, based on specific methods of context and demand analysis upgraded to manage the issue of multi-usage. These analyzes provide the required knowledge to make it possible to begin the production of design solutions.

Secondly, the production and design solution stage have to integrate the user requirements. Nevertheless, it should include the modalities of interaction between users as well as the representation that one can have of the other users in order to promote social presence, usability and representations of users. However, the last element may raise ethical questions. Indeed, the models presented previously (TRA, TPB, TAM, UTAUT) do not originally include ethical concepts such as discrimination, racism or ecology. However, with multi-user centered design, the representations of other users will be included which can induce a form of discrimination. In fact, different discriminations are analyzed, for instance, the gender on a platform for renting accommodation between users - AirBnb - (e.g. Su and Mattila 2020) or the ethnicity (e.g. the first name) on a carpooling application (Carol et al. 2019). Ratings of restaurants, tourist places, hotels, health care personnel are a kind of design solution to help the user to make a representation of the user and significantly influence users' choices but remains ethically questionable because can lead to discrimination. In the same way, this also raises questions of accessibility. A risk of user characteristics profiling is that it may lead to the opposite of universal design. However, a MCD approach taking into account the variability of roles, needs and constraints can be considered as an opportunity to better include the diversity of the users.

Several researchers suggested extensions of existing models by taking into account societal issues: environmental friendly (e.g. Fleury et al. 2017), perceived social benefits (e.g. Hoffmann, Lasarov, and Reimers 2022) security and confidentiality (e.g. Slade, Williams, and Dwivedi 2013). But none of them offer to the best of our knowledge a solution against discrimination impacted by social representations. Thus, we recommend integration of the societal consequences of the product and not exclusively the needs of the users for the MCD. To be able to take into account this issue in any design process, research has to be carried out in UCD. For example, the literature in social psychology is extensive regarding

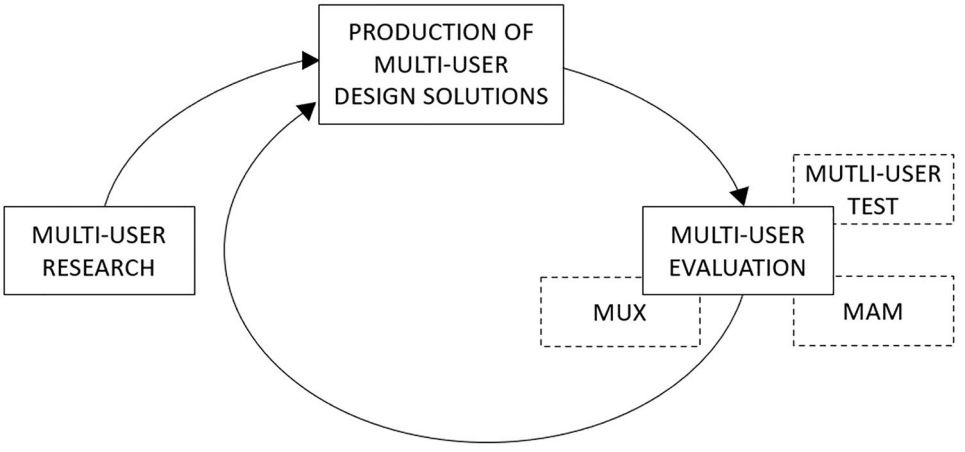

Figure 1. Multi-user centered design (MCD) process.

discrimination bias. In order for this knowledge to become operative in design, guidelines have to be made about designing non-discriminatory interface.

Thirdly, the multi-user evaluation stage included the evaluation of designs against requirements. These evaluations should be based on Multi-user Testing in order to take into account all the social aspects of interactions between users. The use of validated questionnaires for the assessment of MUX or MAM could also contribute to the improvement of the product. The results of these evaluations allow the generation of recommendations for the improvement of the design solution, which lead to iterations between multi-user evaluation and production of solutions.

All of these paths of reflection need to be explored in depth in future studies. Firstly, as a perspective for future research, standardization of new MUX and MAM questionnaires has been mentioned above, as well as validation of multi-user research and multi-user testing methods. More precisely, research could be conducted on the acceptance of digital tools used in collaborative processes that necessitate interaction between very different and complementary profiles, such as distributed participatory open design processes. Research about MAM may also focus on context with high issues in the relationship between the users. For example, the multi-user acceptance of a mobile application of management of medical treatment, favoring the relation and information sharing between the patients and the healthcare professionals could be a relevant field of study to validate the MAM, because of the high demands of trust, privacy and professionalism from the patients to the physicians.

Secondly, beyond the multi-user aspect, ISO 9241-210210 (2019) has to integrate an ethical reflection in order to avoid discriminatory consequences of the uses of collaborative technologies or more generally negative consequences for the society (environmental problems, well-being, etc). This includes adding a preliminary step before user research in order to identify the ethical issue and the final behaviors to avoid (for example, the designer can include in his Multi-user Journey the carbon footprint of each step in order to identify the opportunities for improvement), then a second step during the evaluations integrating a checklist to verify that the ethical criteria are respected. Based on this, design choices can be made to deal with these problems. ISO 9241-210210 (2019) advocates a

systematic analysis by taking into account the context of use (environment, resources, tasks and user combinations) but does not specify the systemic analysis of needs and constraints between users rather than considering users by users i.e. identify areas of convergence, divergence, concordance and discordance. A given user does not only have needs, he/she also has constraints which must match with the other users otherwise the collaborative technology will not be used or only by a part of the user's role that can impact the access to the technology. We have already provided some answers about ways to achieve a solution for different points of view, such as focus groups including users of different profiles, or interfaces versioning. Further research has to develop relevant solutions and practices to deal with these situations where participants have inconsistent expectations of an interface.

To conclude, the new collaborative technologies lead us to rethink the way we design them. The models and methods are not suitable for multi-users and all the constraints that this brings. The scientific tools for updating multi-user design are lacking. In the present article, we propose a general framework for improving the user-centered approach of design. This framework is firstly intended to provide guidance to researchers. It is necessary to add social measures relating to other users in acceptance models and a relational dimension in UX models. The question of the relationship with other users should also be addressed in user research and user testing methods. MCD have to emerges as a new approach that will better respond to the challenges of collaborative technologies in terms of meeting expectations and constraints of users, but also in terms of ethics.

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