Designing for all but with whom? Three cases of codesign with disabled persons

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Ever more firms are adopting participatory design (codesign), which seeks to involve users in the process of innovation. The participation of user groups with specific needs in codesign could be helpful for delimiting these needs, taking them into account and moving toward "universal design". However few approaches mix universal design and codesign; and the reciprocal effects of these two approaches have seldom been studied. In the three cases of codesign with disabled persons reported herein, user participation opened onto a global approach toward universal design that took into account all of a product's aspects and related uses. Specific characteristics of codesign with disabled users are pointed out that are related to the posture and beliefs of both designers and users. Recommendations are formulated for designers; and perspectives for further research, suggested.

On 19 December 2018, the European Parliament adopted the European Accessibility Act for improving accessibility to a large number of products and services, in particular in electronics.[1] This act is intended to induce manufacturers to apply the principles of universal design (also called "design for all" or "inclusive design") so that products and services can be used regardless of the person's age or aptitudes (STORY et al. 1998). A product designed following these principles has to be usable, indiscriminately by someone in a wheelchair, by the elderly or by a person with an intellectual disability.[2]

For this purpose, methods and codes of good practices already exist, and some member states are starting to make them mandatory. In France for instance, the RGAA lays down the criteria of accessibility for public service websites and applications (*cf.* Table 1). There is a trend toward standardizing the practices related to universal design. Thanks to standards, the visually impaired can easily increase the size of characters on a website; persons using speech synthesis systems can more easily browse contents; the dyslexic can access webpages with adapted fonts; etc.

Table 1: Accessibility: Standards and regulations

In 2005, a French equal rights act provided that "*establishments receiving the public*" (ERPs) and the websites of public services and big firms will have to be accessible to all, in particular to the disabled. For buildings, a stay of ten years was granted for compliance with the law. In 2014 however, a new act softened this requirement by granting three more years to ERPs, and up to nine years for the biggest among them and for those in rail transport.

Accessibility to the Web and digital devices is not a new topic. During the 1990s, the World Wide Web Consortium (W3C) launched the Web Accessibility Initiative, which, in 1999, released the *Web Content Accessibility Guidelines* (WCAG) (updated in 2008 and 2018: WCAG 2.0 & 2.1). In France, ten years after the first WCAG, the General Specifications of Accessibility for Public Administrations (RGAA, Référentiel Général d'Accessibilité pour les Administrations) were published in 2009. However not all public administrations met the first deadline (2012) for the compliance of their websites. A new deadline, 2019, was voted; and controls of websites were scheduled to start in 2020 for websites and in 2021 for mobile applications.

[1] Council of Europe press release: https://www.consilium.europa.eu/en/press/press-releases/2018/12/19/more-accessible-products-and-services-for-eu-citizens-council-approves-the-provisional-agreement-with-the-european-parliament/.

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Meanwhile, more and more firms are involving users in their processes of innovation, thus reaping benefits in terms of customer relations, the acceptability of their products and the creativity of their teams in design (LE NAGARD & RENIOU 2013). Among other examples: manufacturers are allowing customers to design their own watches (FRANKE & PILLER 2004); firms in new technological fields (such as Nokia or Dell) are gathering ideas from customers (COVA 2008); and sporting goods firms are drawing inspiration from the tweaks and repairs that users make to their equipment (HALLÉ *et al*. 2016, LÜTHJE *et al*. 2005). These examples of participatory design ("codesign" or "cooperative design") seek to tap users' inventiveness and knowledge so as to provide a better response to their needs. Since one objective of universal design is to take into account users' needs, including when the latter are very specific or quite different from normal needs, the participation of persons with disabilities in the design process might, we assume, be taken for granted. However there are few actual examples.

What does participatory design, when it involves users with disabilities, bring to universal design? To answer this question, three cases are presented from a research intervention program conducted by APF Lab, an association that promotes projects of codesign with the participation of persons with disabilities. This article starts by describing universal and participatory design. While universal design wavers between a proposed or imposed deployment, codesign is still asking questions about the choice of the "right" users for involvement in its procedures, about how representative they are. After an account of our research program's methodology, we report our findings from the field on the three cases of participatory design studied. The analysis of these cases has brought to light the complementarity of participatory and universal design, while drawing attention to points to bear in mind persons with disabilities take part in a participatory approach. We conclude with recommendations for designers and suggestions for future research.

Universal and participatory design: Two methods for responding to users' needs

How to detect users' needs has long been a key preoccupation in firms, especially during the phase of product design. The aim of universal design is for products to be invented that respond to everyone's needs, while participatory design (or codesign) postulates that these needs can be identified by involving users in the design phase.

Universal design: Between proposing and imposing

The concept of universal design was invented during the 1980s in the United States (MACE 1985), at a time when handicaps were starting to be described no longer as an individual's mere medical condition but as an interaction between individuals and their environment (FOUGEYROLLAS *et al*. 1998). This paradigm switch was important: the intent was no longer just to "repair" individuals but to arrange places and adapt products so that people, regardless of their characteristics (age, size, sensorimotor or intellectual aptitudes, etc.), are able to use them. Universal design is the "*design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design*" (MACE 1985).

Table 2:The seven principles of universal design (in brief)

1. "*Equitable use*"	Any user should be able to use the product, regardless of his/her age, size or aptitudes, without being stigmatized.
2. "*Flexibility in use*"	A product can be used in varied ways that are adapted to the user's "*preferences and abilities*" (*e.g.*, with the right or left hand or with the voice instead of touching).
3. "*Simple and intuitive use*"	A product should be easy to use from the very start, "*regardless of the user's experience, knowledge, language skills, or current concentration level*".
4. "*Perceptible Information*"	The information necessary for using a product should be provided, including to persons who see or hear poorly or have difficulty reading or understanding, while "*maximizing legibility*".
5. "*Tolerance for error*"	A product should minimize the risks of faulty manipulation and should not be dangerous if used incorrectly. It should warn users of errors and enable them to go back to the previous state at any time.
6. "*Low physical effort*"	A product's use should "*minimize sustained physical effort*" and allow for rest periods, if needed.
7. "*Size and space for approach and use*"	The product should be easy for anyone to access, regardless of users' and their assistants' size and position (sitting or standing).
Source: CONNELL *et al*. (1997) & https://projects.ncsu.edu/ncsu/design/cud/about_ud/udprinciplestext.htm.	

This current of thought had operational effects as of the 1990s. The Center for Universal Design drafted a set of seven principles (CONNEL *et al*. 1997). As we see from the list of these principles in Table 2, universal design centers on the idea of "usability". Much more detailed recommendations have, as explained in Table 1, been proposed to, or imposed on, designers (*e.g.*, VANDERHEIDEN & JORDAN 2012) and Web developers — evidence of a standardization trend in guidelines for designers.

Intended in theory for as broad an application as possible, the concept of universal design focuses on the needs of the disabled. Its founding texts lay emphasis on users with disabilities (WINANCE 2014). In 2006, Article 2 of the UN Convention on the Rights of Persons with Disabilities (CRPD) defined and defended this concept: "*'Universal design' means the design of products, environments, programs and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. Universal design shall not exclude assistive devices for particular groups of persons with disabilities where this is needed.*"

In contrast, more recent methods have underscored this approach's universality and no longer consider it to be specific to the development of products for the handicapped (OSTROFF 2011). On the one hand, some articles (VANDERHEIDEN & JORDAN 2012) have emphasized the size of this market (20% of the population has a disability, and 64% of persons over the age of 75 cope with functional limitations) and the multiplier effect (A very large proportion of families with three or four persons on the average are coping with functional limitations). For another, the HUMBLES method (ARAGALL & MONTAÑA 2011) has drawn attention to the financial opportunities underlying universal design: more customers, higher sales (exports and tourism), improved corporate image, etc.

Universal design does not, therefore, just take account of the needs of a narrow slice of the public. It postulates that a firm can respond to the needs of all by looking closely at the extremities of the spectrum of needs. From this perspective, involving persons with disabilities in participatory design looks like an opportunity for firms.

Participatory design: Whom to involve?

The idea of "cocreation" or "codesign", usually attributed to Prahalad and Ramaswamy (2004), refers to the practice of having third parties (users, suppliers, researchers, etc.) from outside the firm take part in developing products and services. User participation in product development was studied well before the concept was coined however. Participatory design, which was born in Scandinavian industry during the 1970s, already called for user participation in design (EHN 1988). The recourse to "lead users" originally proposed by Eric von Hippel (1986), was initially worked out for business-to-business relations before being extended to relations with customers. It was based on the idea that some especially creative users could help a firm imagine new products.

The question thus arose about the profile of the users to contact for participation in codesign programs. Buisine et al. (2017) have an original view on this question: for innovation, "extraordinary" users have to be implicated who are "out of synch with the target population" (children, the disabled, the agèd, etc.). Since they are not familiar with a product, they can better focus on the primary needs it is to satisfy, which other users have forgotten because they have adjusted to its shortcomings and defects. Several research programs have concentrated on the recruitment of these "lead users" and described their profiles — such users are few and far between in the crowd of all users (FRANKE et al. 2006, MORRISON et al. 2004, VON HIPPEL et al. 2009). Nonetheless, the uses and needs of these lead users, who are experienced, creative trendsetters, are not necessarily representative of ordinary users'. Ordinary users also have a role to play in innovation (MAGNUSSON 2009): even though they might not be conveyers of radical innovations, they can inspire designers during brain-storming sessions and help firms draw up new strategies. Like lead users however, ordinary users are not representative of users in their full diversity (LESPINET-NAJIB et al. 2017). This diversity is what universal design seeks to take into account.

Despite this emphasis on the value of having users represented in universal design procedures (PARK et al. 2014, YELDING 2003), the proof of this contribution is still, to the best of our knowledge, lacking. More broadly, "at present, the approaches combining the design-centered user and universal design are few in number" (LESPINET-NAJIB et al. 2017).

What happens if we combine universal design with participatory design involving the disabled? Since universal design entails taking account of specific uses, which might be far from any "average" use, we wanted to observe the results of involving users with disabilities in participatory design programs.

Methodology

The literature provides few descriptions of programs mixing universal and participatory design. Such programs hardly exist in organizations despite the increasing recourse to user participation in innovation. Thanks to codesign workshops, we were able to observe and understand the complementarity between participatory and universal design.

Our research-intervention was conducted within APF France Handicap (*cf*. Table 3) in 2018 and 2019. This association recruited one of the authors under a contract (CIFRE) for a research program on the participation of persons with disabilities in innovation. APF Lab was created, an "innovation unit" that would operate like an itinerant living lab. It responds to queries from firms that want to conduct a codesign program involving the handicapped. With the help of the association's establishments, this author formed user groups and attended or led codesign workshops. Hereafter, the phrase "APF Lab program leader" refers to this author.

Table 3: APF France Handicap, its origins and role

APF France Handicap (formerly Association des Paralysés de France) is an association with managerial activities but that undertakes advocacy for the rights of persons with disabilities. It manages 400 establishments (health care and social work) and 50 firms and establishments (ESATs) with specialized work programs. Its advocacy activities are conducted with the support of 25,000 members via approximately 50 branch organizations throughout the country. All this has made APF France Handicap the second largest nonprofit organization in France. In 2018, in response to requests from firms and to defend its expertise, APF France Handicap set up APF Lab to involve its members and users in innovation processes. Since 2018, APF Lab consults with firms of all sizes on their codesign programs and helps to bring them into contact with persons who might be far removed from ordinary socioeconomic activities.

The exploratory analysis proposed herein is based on three case studies of participatory design involving persons with disabilities. The case study method (YIN 2002) was used to describe the context and provides examples of how participatory design, when conducted with persons with disabilities, contributes to universal design. Given this exploratory approach and the density of the data collected, a qualitative methodology was chosen (DUMEZ 2016). Several types of data were put to use: the reports on interviews with firms and on preparatory meetings; e-mails about organizing workshops; recordings of workshop sessions; a detailed field journal of each session; an *ex post* evaluation by the firms about the benefits of these sessions (notes on telephone conversations eventually along with a grid of evaluation or a report).

The three cases were selected out of the nine participatory design workshops conducted by APF Lab since it was set up. Our interest in universal design guided this choice, since these cases involved products that were not just for the disabled. Two of them focused on products for the general public; and the third, on a product for the elderly that was to be adapted to persons with disabilities. Table 4 presents these three cases.

Table 4:The three cases of product design (an overview)

	Check deposit machine	***Photocopier***	***Video game for motor rehabilitation***
Phase in product development when the firm contacted APF Lab	Advanced prototype	Product already on the market	First version for the elderly already brought to market
The firm's goals	Improve the user experience and boost universal design	Boost universal design	Improve the user experience and adapt the game to motor handicaps
Place of meeting with users	A specialized housing center in Paris	An "adapted firm" in Choisy-le-Roi	A specialized center in Garches
Period	April to May 2018	May 2018 to February 2019	2017 to July 2018
Workshop date	17 May 2018	13 February 2019	19 July 2018
Workshop duration	2 hours of tests	3 hours of tests after several weeks of use	2 hours, preceded by several months of use and by interviews with individuals
Procedure	Test with scenarios	Test with scenarios	Brainstorming
Author's position	Facilitator	Leader	Co-leader
Persons in attendance (besides the author)	Designer, head of product development, an occupational therapist and six potential users: persons in a wheelchair (manual or electric), including one with a speech impairment, one who was not verbal and had very limited use of the upper limbs	A salesperson, RSE representative and ten potential users: persons with various motor disabilities (upper or lower limbs, wheelchair, etc.), some of them cognitively impaired	CEO and four potential users: persons in a wheelchair (paraplegia, tetraplegy, degenerative diseases)

Participatory design involving persons with disabilities

Case 1: Making the deposit of checks accessible to everyone

At the end of April 2018, a design and innovation consultant from a bank contacted APF France Handicap. His team had designed a new installation for depositing checks, and he wanted to "submit it to an association of persons with limited mobility". One of the bank's directors, aware of the issue of accessibility, always asked that new products or services be tested by persons with disabilities. The request was urgent, since the consultant wanted the test to be done within two weeks. A first meeting by telephone was organized on 2 May between the bank's representatives and two persons from APF France Handicap (including APF Lab) in order to better understand the request. The bank's representatives said that their request concerned only persons with limited mobility, the needs of the visually or cognitively impaired being handled via other channels. They needed at least five (ideally eight) users, and wanted members of APF France Handicap to come to the bank agency to test the check deposit machine.

APF Lab was in charge of organizing the test. Since it turned out to be very complicated to receive persons in a wheelchair in the agency, we deemed it better to have the machine moved to a specialized housing center in Paris managed by APF France Handicap. APF Lab contacted the center's director, who enthusiastically accepted this suggestion right away. Jointly with the center's director and a designer from the bank, APF Lab organized a workshop on 17 May. The designer drew up a test scenario.

The project leader from APF Lab arrived at the housing center at ten o'clock Thursday morning for the workshop. The center's residents were finishing breakfast in the dining room. This center houses 56 persons with motor disabilities (with or without other problems: speech disorders, spasms, involuntary movements, breathing difficulties, etc.). The test was conducted in the lobby, a place where all residents passed. A poster was placed on the elevator: "Test a new machine for depositing checks."

Before the arrival of the machine and the bank's representatives, a few residents in a wheelchair approached: "Is the machine going to be installed in the neighborhood?" The APF Lab program leader said that the machines were to be installed in all agencies throughout France. She also explained participatory design. One resident said, "What's necessary is to be able to place our legs under the screen. Otherwise, we can't get close enough." Others soon added, "And the screen shouldn't be too high" and "We sometimes don't have room for maneuvering."

The design team from the bank (a designer and project head) soon arrived with the machine. A small crowd drew near. The team set up the machine (which had a solid plastic base, a tablet and a slot for depositing checks, cf. Figure 1) and then recounted the reasons for it being there and the test protocol: each tester would deposit checks.

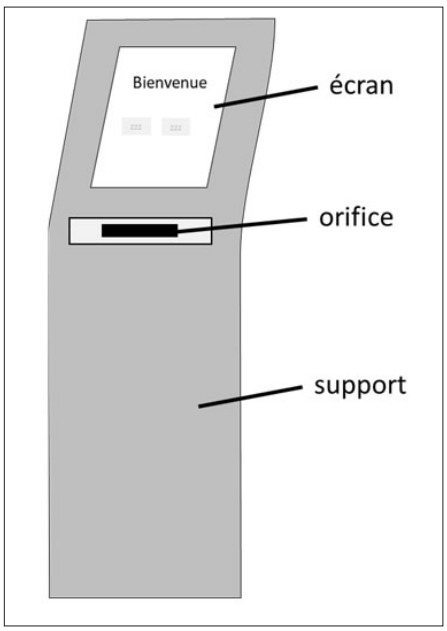

Figure 1: The check deposit machine (authors' drawing).

The first tester was a man with a speech impairment. The designer explained the test scenario. She was very attentive and helped him perform the different actions. He had trouble using the touch screen. Despite his electric wheelchair (with adjustable height), he said it was hard to access the machine front-on. He pointed out that the screen was too high for short people.

Although the second tester had a similar wheelchair, she remarked that many people have a wheelchair that cannot be adjusted for its height. Unable to position herself in front of the machine, she approached it from the side. She pointed out that anyone waiting behind her in the agency would be able to see everything she was typing.

A woman in a manual wheelchair tested the machine next. The screen was too high; she was unable to touch the target on the screen for "deposit checks". She also had trouble reading what was written on the screen because it was oriented upwards. Furthermore, the fingerprints left on the screen made it even harder to read from her position. The designer helped her finish the test.

Two other persons tested the machine. The final tester was in an electric wheelchair and could not communicate, not even by nodding her head. She had sudden muscular contractions, spasms that forced her to curl her hands. The APF Lab program leader hesitated to have her take part in the test, since she was not sure of her consent to, and understanding of, the test protocol. This tester followed all the instructions given by the designer, but encountered major difficulties when she had to press the touch keys on the tablet.

The APF Lab program leader asked the design team what they thought of participants' remarks. Despite the help given to participants and the last user's difficulties, the team observed that everyone had managed to deposit checks. The bank's project leader talked about the technical constraints: the system was hidden in the bottom of the machine, which would not be very stable had it been placed in the top. Furthermore, the machine was to be installed without being fixed; and this meant that it had to have a solid base.

An occupational therapist who worked at the center came to express her opinion. Her tone of voice was much more assertive than the others'. She wondered whether the machine was worthwhile: persons in the center did not make check deposits, such deposits were obsolete, the machine did not respond to any need, and so forth. She then pointed out that the machine could not be approached from front on with a wheelchair. The project leader from the bank explained, once again, the technical constraints, but the therapist insisted that the system could be placed on the side or behind. She showed the designers that, when accessing the machine from the side, the elbow was in the way. She also dwelled on the slot for depositing checks: it had to be bigger. The designers explained that, since a check had to be deposited vertically, it would be hard to make the slot bigger but that it could be placed much lower and made with a material that made the act of depositing easier.

About ten days later, the APF Lab program leader asked the designer from the bank what improvements would be made. The software would be modified so that certain commands be placed lower on the screen; and a jack plug would be added for voice commands. She explained that it was impossible to make the slot bigger and too late to modify the machine's base so that persons in a wheelchair would have room for their legs.

Case 2: A photocopier that can be used by everyone

In May 2018, a manufacturer of photocopy machines contacted APF France Handicap to obtain a "label of accessibility" for a new model. He used to have commercial relations with APF Entreprises Adaptées. He said that he had been following a universal design approach for more than twenty years and that several modifications had been made to his previous line of photocopiers so as to improve accessibility and usability for persons with disabilities (larger handles, a lower screen, speech synthesis). So, the manufacturer wanted to draw attention to his efforts by obtaining a label. APF France Handicap did not, at the time, have such a label. However the association did propose that the manufacturer enroll in APF Lab's participatory design program, and he accepted.

APF Lab was in charge of organizing the test. The manufacturer had, several times, to be reminded of the purpose of testing: to test accessibility to the photocopier with the aim of improving it (and not to validate the product's accessibility). He said he was interested in the tests. APF Lab found an "adapted firm" within APF Entreprises Adaptées, that volunteered to host the test. In an "adapted firm", at least 80% of wage-earners have disabilities, and the firm receives government subsidies. In this firm, 150 persons with disabilities were working, providing various administrative, logistic and maintenance services to client firms. APF Lab contacted the firm's director to agree on the modalities for the test. During a meeting organized with the manufacturer to define the methodology, test scenarios, based on a preparatory grid from APF Lab, were worked out. Eleven commands were to be tested: scan a document for a new addressee, replace the toner, copy a color sheet in black and white, etc.

The workshop was organized on a Wednesday morning in February 2016 on the adapted firm's premises. The photocopier had been installed a month earlier so that employees could test it. A wage-earner in the firm had drawn up a list of ten users, all of them employees who would take part in the test. Throughout the morning, she would go to fetch them by groups of three or four. Eight of the testers had already used the machine; two had not. The APF Lab program leader, who led the test session, proposed different scenarios. To avoid skewing the test's results, the two representatives of the manufacturer stayed on the sidelines.

The test started with a wage-earner who had difficulty maintaining a standing position, had little strength in his hands but did not have any cognitive or intellectual disability. He hesitated during the test, often turning toward the APF Lab program leader to say in a low voice, "I don't know how to do it […] Do I press that? […] In this direction?" He did not criticize the photocopier however. On the contrary, his voice was clear when talking about what was positive, for instance the directions for changing the toner: "I saw the arrow. That's very clear!" He went through the full test but had trouble entering the addressee for the scanner.

The second user was paraplegic. He was to make a recto-verso photocopy, a feature not easy to find. However he easily changed the toner. The third participant could not use her right hand. She easily manipulated the sheets of paper and the hood. She too had problems performing the recto-verso test and adding addressees to the scanner. During the test with the fourth participant, the same difficulties cropped up. The previous participant reacted out loud, "I thought it [the button] was well hidden too. That reassures me."

During the rest of the testing, participants supported each other. Together, they tried to find the complicated features that some had failed to locate. Other potential improvements were suggested: displaying a confirmation message once a task was launched, making it easier to open a new box of toner (The boxes were closed with an adhesive), making the on/off button more visible and accessible (It was on the side of the machine), etc.

Following the test, the manufacturer wrote a report that listed the photocopier's observed shortcomings and proposed improvements. The recording made by APF Lab and the journal it had written just after the test provided significant information to this report, which swelled from three to five pages. The manufacturer said

that the report, written in French, would be sent to his R&D department, located in Japan, so as to improve the next version of the photocopier. He wanted to make a press release about the test right away.

Case 3: Adapting a video game for motor rehabilitation

The video game for rehabilitation involved detecting movements and proposing recreational exercises for muscle movements, exercises that could be fully customized in relation to the player's mobility. For example, a player could direct with his arms or shoulders the movements of a boat that had to avoid obstacles. The game had been designed for the elderly and was sold in nursing homes. Since the firm in charge of sales wanted to adapt it for persons with motor disabilities, it contacted APF France Handicap for experiments to be carried out in several establishments.

The game had been used for several months in a specialized center[3] located in the greater Paris area. The staff of APF France Handicap wanted APF Lab to join and monitor this experimentation. During our first interview, the game's designer explained, "In fact, the game is for care-givers. So it's necessary to talk to them." The game, as adapted for rehabilitation, was intended for use as a complement to the practices of physical therapists, educators and other health-care personnel. The designer had already conducted several interviews with disabled users of the game and with health-care professionals.

For more feedback on the product, APF Lab organized a brainstorming workshop to produce ideas about how to integrate new movements in the game and its scenarios. It organized several meetings between April and June 2018, prior to the workshop: a meeting at the specialized center to become acquainted with its staff and with users of the game and to observe a gaming session, a meeting on the logistics for the workshop (date, place, participants and their specific needs), and two meetings with the game's designer to review the activities proposed by APF Lab for the workshop.

The workshop took place on 19 July 2018. When the designer and the APF Lab program leader arrived at the specialized center, a care-giver fetched four participants (fewer than what was expected). APF Lab's role and the workshop's objective were presented to them. The workshop was led by the APF Lab program leader, who asked participants to describe what would be their worse experience with video games for rehabilitation. The group took time before responding. A young woman talked about her fear of falling. The others mentioned their fear of pain or fatigue during and after the game. These fears cropped up frequently during the discussion. We realized that pain was a daily preoccupation for participants. Consequently, the other subjects they mentioned seemed superficial, such as that the objectives for rehabilitation were not clearly defined or that the game was not interesting or recreational enough.

[3] *Maison d'accueil spécialisée* (MAS), which accommodates persons of all ages who have serious motor handicaps and are very dependent.

Nevertheless, what was said sufficed to move on to the workshop's second phase for converting these "worse experiences" into needs. This brought to light other needs. Priority was given to three features for: playing with several persons at once, starting the video game without assistance, and making the game more stimulating.

In fact, the game had not been used much in the past few weeks. The care-giver explained that the game was too easy and players caught on too quickly. The leader of the APF Lab program asked participants about this. They said that the game required the presence of an assistant in order to start it but that no one was available.

The last exercise proposed to the participants was to imagine the ideal video game for rehabilitation. The exercise was hard. Although two participants apparently did not have the energy necessary for it, they did mention the need to visualize the "right gestures" before playing. In addition, these two paraplegics referred to the needs of persons with disabilities different from their own: being able to use a single arm, to play with the head or to play while standing. The proposals from the two other participants hinged on escapist fantasies; they imagined a "game of climbing, fast and intense, in virtual or augmented reality".

After the session, the designer said that the proposals made were not new and would not modify his product development plans. A few months later however, a fast-launch model for starting the game without the assistance of a care-giver was brought out. It had not figured in his initial plan.

The conditional benefits of combining participatory and universal design

What does participatory design bring to universal design? To answer this question, we shall examine some of these contributions and then explain a few points specific to participatory design when it involves persons with handicaps.

What does participatory design bring to universal design?

In each of the three cases, the codesign sessions conducted with disabled persons produced ideas for improving the products in line with the principles of universal design. In Table 5, which arranges the improvements suggested by users during the workshops in relation to the principles of universal design, we see how participatory design contributes to universal design. As we notice, two principles of universal design were not mentioned:

- The principle of simple and intuitive use was not mentioned for the check deposit machine. This was a direct consequence of the assistance provided to users during the workshop.
- The principle of the size and space for approach and use was not mentioned for the video game, since care-givers or, during the workshop, the game's designer had launched the game.

Table 5: Product improvements in line with the principles of universal design

Principles of universal design	***Product improvements suggested during the workshop***		
	Check deposit machine	***Photocopier***	***Video game for motor rehabilitation***
1. Equitable use	The improvements suggested would enable persons in a wheelchair or with motor impairments of the upper limbs to use the machine.	The suggested improvements would make the machine easier to use for everyone, in particular for persons with cognitive or intellectual disabilities or with motor disabilities in the upper limbs, and persons in a wheelchair.	The improvements suggested would make it possible for hemiplegic and tetraplegic persons or persons with motor disabilities in the upper limbs to play the game.
2. Flexibility in use	— Add a jack plug for connecting earphones. — A tiltable screen.	— A tiltable screen.	— Make it possible to play with a single arm, with the head or in a standing position.
3. Simple and intuitive use		— Simplify the procedure for entering the addressee for a scan (the names of features, the keyboard's ergonomics). — Improve the visibility of the most frequently used features (in particular, rec-to-verso printing). — More consistency in the terms used for features.	— Make it possible to start the game without assistance from a care-giver.
4. Perceptible Information	— Make it possible for persons in a wheelchair to read what is on the screen (by making it tiltable).	— A confirmation message after launching a task. — A more visible pointer.	— State the objectives of rehabilitation. — Display the "right" gestures at the start of the gaming session.
6. Low physical effort	— Improve the touch screen to limit the effort and precision required. — Position the screen low enough to limit arm movements. — A bigger deposit slot. — Place the slot lower on the machine.	— Make it easier to close the hood that accesses the area where paper jams. — Make it easier to open new boxes of toner.	— Limit pain during and after gaming.
7. Size and space for approach and use	— Be able to place one's legs under the screen and approach the machine front on. — Be able to maneuver a wheelchair around the machine.	— Make the on/off button more accessible to persons in a wheelchair.	
Other hoped-for improvements			— Make the game more recreational: a variety of scenarios, the possibility of playing it with others, virtual reality, etc.

Two of the firms (cases 1 and 2) said they complied with "accessibility standards" during product development. Both were in the private sector where these standards are not mandatory. The bank asked users for their opinions in a neutral way, whereas the manufacturer of the photocopy machine was interested in using his support for universal design as a sales argument and in pushing the rationale for standardization to its limits by soliciting a label from APF France Handicap. In any case, both firms had adopted an approach that partly fell in line with universal design. The designers of the check deposit machine had followed all recommendations about software but while overlooking the problems of accessibility to the machine and to the slot for depositing checks. In contrast, the designers of the photocopier had focused on the material parts of the machine (handles for drawers, the weight of movable parts, etc.) without working on the software interface to make it simpler to use. During meetings with users, questions soon cropped up about accessibility to the deposit machine and about the photocopier's software.

In the case of the third firm, the designer had concentrated on adapting the video game (initially designed for the dependent elderly) to users' physical disabilities (such as being able to move only the head). Here too, the meeting with users enabled him to take account of aspects that he had overlooked: the game's recreational aspects and accessibility in terms of being able to start a gaming session.

User participation opened toward a holistic approach to universal design, an approach that takes into account all aspects and all uses of a product. In all three cases, a small group of persons with motor disabilities (4-10 users) came up with definite suggestions for improving accessibility for everyone. This contradicts the idea that the diversity of handicaps is an impediment to universal design and to the relevance of involving persons with disabilities in product development (NEWELL & GREGOR 2000). Two explanations back up this remark.

The first has to do with the relatively limited maturity of universal design as applied in these three firms. Had the firm followed universal design more closely upstream during product development, it would have, we assume, ended up detecting the contradictions in the needs expressed by users. In the case of the firms with an approach not fully in line with universal design, no questions were asked about the representativeness of involving users with disabilities in participatory design. On the contrary, the involvement of these users significantly improved the universality of the three products (LIETDTKA 2015).

The second possible explanation is that some participants in these codesign sessions were all the more representative insofar as they all adopted an "interhandicap" approach. Their experiences, probably shaped by their proximity with other disabled persons, had given them a particular sensitivity to all problematic situations in using the products tested. In each of the groups, users mentioned the needs of persons with disabilities different from their own.

Tests and workshops with users might reveal nothing that designers do not already know, as was the case during the brainstorming session for adapting the video game. After the workshop, the designer declared that he had not identified any new needs and had not modified anything in his product development plan. Nonetheless, a few months later, he developed a fast-launch model, as users had suggested. After the test of the check deposit machine, the designer said that she knew "*there was a problem with the screen height*". Furthermore, the decision was made to modify the position of the buttons so that they be more accessible to persons in a wheelchair. It is as if exchanges with users were necessary to move from the awareness of a problem toward the decision to deal with it.

Involving persons with disabilities in participatory design

From these three cases of participatory design with disabled persons, we can draw attention to several points to which anyone who organizes this sort of procedure should be attentive.

Take the opinions of experts into account, but not just their opinions

In the cases of participatory design under study, the opinions of health-care professionals carried too much weight. In general, an innovation in the health field is intended for use by more than one sort of user. Let us not forget the persons who prescribe the product, those who buy it, those who use it, those who help someone use it, those who pay for it. The video game, for example, was intended to be used not only by the disabled but also by their care-givers, for whom the game was a tool for rehabilitation.

But even when there is a single sort of user, more store is set on the expert's opinion. Recall the physical therapist's opinion about the check deposit machine. During the interview at the end of this workshop, the designer only mentioned the remarks made by the therapist, who was present for 15 minutes during a test that lasted 90 minutes. There are three possible reasons why more importance is given to these persons:

- Health-care professionals are seen as "persons who know". Furthermore, their posture is much more assertive, critical and directive than that of persons with disabilities (*cf*. the case of the physical therapist venting her opinion about the check deposit machine).
- Designers, for sure, feel closer to able-bodied professionals than to persons with disabilities, whose situation they do not share. Furthermore, they adopt a professional posture during meetings.
- The "posture" of the participants testing the products reinforced, for sure, the tendency to lend too much weight to the opinion of professionals. the users with disabilities who tested the photocopier or the check deposit machine excused themselves when they did not succeed, as if they felt that they or their ability to use the product were being judged.

The weight given to the expert's opinion, even more so when persons with disabilities lend it more weight than their own, can be a factor affecting participatory design. As illustrated in the case of the video game, when the question cropped up about why users had left off playing the game, the expert's perception of the situation was different from the user's — without necessarily being more pertinent.

Do not overlook the social acceptability of products

A handicap leads to experiences that might be marked by feelings, in many cases, of failure and, sometimes, of the wearisome gaze of others (LE BRETON 1991). Once the last participant with reduced mobility in the upper limbs had tested the check deposit machine, after trying repeatedly to press the tactile targets, the designer said with satisfaction, "*Everyone has been successful in the test.*" However the most probable consequence of the difficulties experienced by this last participant is that she will never use a machine that placed her in difficulty by herself, lest she make other persons at the bank wait and attract attention to her disability. By the way, this might be the reason why many residents at the center where the workshop was held do not go to the bank. In the case of the deposit machine, designers had a hard time imagining how persons with disabilities deal with failure. As a consequence, they had difficulty evaluating the machine's social acceptability.

In the photocopier test, the firm's representatives wanted to have the accessibility of physical elements (handles, knobs, doors) confirmed but seemed to consider as secondary difficulties stemming from the software (*e.g.*, finding the recto-verso feature). However persons with a motor handicap who have experienced repeated failures with objects are going to be less tolerant of the complexity of use; and poorly designed software is probably going to hinder them from using an object, even if the latter is physically accessible. In this case too, the attention given to a product's social acceptability was crucial for both persons with disabilities and "able-bodied" users, since no one likes to experience a failure when manipulating a device. Persons with disabilities magnify a requirement shared by all.

Do not help (too much)

The workshop leaders sometimes provided users with assistance, explanations or suggestions — thus creating a situation far from the user experience in real life. This skewed the tests. The designer detailed too much the steps for depositing a check: "*Now, press this button and put the check in the slot.*" Likewise, the APF Lab program leader oriented users who did not find the photocopier's recto-verso feature or had trouble entering an addressee for scans. This tendency to help users more than needed has already been described; it is not limited to the cases studied herein. It is augmented by the presumed or actual fragility of users with disabilities. How not to be tempted to help someone who has trouble pressing a button because of a lack of motor control in his hands? How to let someone with cognitive impairments get lost in the printer's menus without intervening? The impairments of the disabled directly affect the attitudes of the persons who lead test sessions.

This "excess" help proffered to participants during tests negatively affects a product's usability assessment. Nielsen (1993, p. 183) recommended: "*During the test, the experimenter should normally not interfere with the user but should let the user discover the solutions to the problems on his or her own. Not only does this lead to more valid and interesting test results, it also prevents the users from feeling that they are so stupid that the experimenter had to solve the problems for them. On the other hand, the experimenter should not let a user struggle endlessly with a task.*" In line with this recommendation, we would like to emphasize an important point: be fully aware of any help provided to users so as to take it into account when evaluating product usability. During the test of the check deposit machine, users were guided step by step, and the team drew the conclusion at the end of the workshop that everyone had managed to deposit a check. In contrast, the assistance provided to users of the photocopy machine did not keep the team from identifying the features that caused problems.

Recruit voluntary users and involve them early in product development

Much research has referred to the value added to a product thanks to the involvement of users upstream in product development, during the phase of design. Despite the ergonomic improvements made to the photocopier, many more (presumably less expensive since they concerned the software) could have been made had users been consulted prior to commercialization of the machine. In the case of the check deposit machine, an early involvement of users would have led to identifying the problems of screen height and leg placement under the screen. These two improvements were mentioned by users who had not yet seen the prototype and did not all manage their own banking accounts. The experience of a handicap endows users with an expertise greater than that stemming from a repeated use of the product.

The question of the best user profile for running tests remains standing. The workshops conducted in this research-action program involved users with all sorts of motor (and eventually cognitive) disabilities. In the case of the check deposit machine, a person who could not speak and had no other means of expression passed through the test scenario; and the observation of her motor difficulties provided information about the machine's usability. A person who had memorization problems helped us realize why it was too complicated for everyone to enter a new address for sending a scan. Disabilities were a litmus test for detecting defects in design. The more a person is in a situation of being handicapped, the more these defects are evident.

The way users are recruited might be as important as their profile. The persons involved in our tests had been recruited in different ways:

- For the check deposit machine, participants were alerted about the organization of the test through a poster in the establishment. The machine was then set up in a place of passage and the persons who were interested took part.

- The photocopier had been set up in the adapted firm a month prior to the test, and the director had asked wage-earners to use it. One wage-earner then asked to take part in the half-day of testing.
- For the video game, no user came to the workshop spontaneously. The staff person went to ask four users to take part.

Users taking the initiative to participate in codesign was, therefore, total in the first case, very relative in the second, and next to naught in the third. In fact, for the video gaming workshop, there was difficulty involving two of the participants, who did not seem much interested in the tests, probably because they had more pressing preoccupations with their health. For the photocopy test, the results were variable enough from one user to the next. We can thus formulate the hypothesis that a prerequisite to participatory design is that users take the initiative to become involved. Participation should be voluntary.

Conclusion: Implications for management

These three cases show how participatory design can contribute to product development in firms that want to follow the principles of universal design. Involving persons with disabilities in product development from the phase of design is valuable given their specific experiences, their sensitivity to defects in design (in particular their intolerance of failure) and their empathy for persons with handicaps of all sorts. We would like to make a few recommendations about: the posture adopted by designers, the specific characteristics of persons with disabilities, and the right time for introducing participatory design.

First of all, the posture adopted by designers significantly affects the outcome of participatory design. The help they give to users testing the product should be in the "right dose". Furthermore they should pay attention to not just the product's usability but also its social acceptability and the perceptions of others. Designers should ask questions about how much weight is given to what users feel in comparison with professionals' opinions.

Secondly, the participatory design procedure should take into account characteristics directly related to the disabilities of the testers. In our research, the three workshops were organized at the place where these persons worked or lived, so that they not be forced to go out. Tests should be carried out under conditions as realistic as possible. For example, the check deposit machine had been set up in the corner of the room and not in the center, as it would have been in a bank agency. Furthermore, when the tests allowed for persons with speech impairments to take part, closely observing the test was more important than users' comments. Attention should be paid not only to the characteristics specific to the testers' disabilities but also to their emotional characteristics, their relation to failure and the possibility that their creativity might be invisible owing to their personal preoccupations with health issues, which, of course, override any other objective.

As these three cases show, participatory design with (potential) users is more worthwhile when it takes place upstream in the process of product development. The check deposit machine's base could no longer be modified even though its shape caused an obvious problem of accessibility. Likewise, it was apparently too late for the manufacturer to have the defects in the photocopier's software corrected. When product design is already too advanced, designers pay less attention to user feedback and are tempted to declare that the prototype presented is the right choice.

One way to measure the value added by participatory design is to compare product development plans before the program and a few month afterwards. Participatory design sometimes leads to adding an element to product development, this already representing a real, concrete contribution.

There are many perspectives for future research on these questions. It would be worthwhile for a larger study to confirm the contribution of participatory to universal design. As we have shown herein, persons with disabilities bring to design a knowledge of handicaps that is valuable for designers — under condition that it is brought into product development at the right time. It would be worthwhile also examining the benefits for (presumably able-bodied) users and, too, for the persons with disabilities involved in participatory design (as a function of their handicap). What do persons with disabilities retain personally from being involved in product usability tests? It would be interesting to conduct participatory design programs with persons with varied handicaps (motor, sensory and intellectual), in particular to understand at what point the representativeness of users in tests becomes an important issue. Finally, studies could also be made of how firms understand universal design and implement it; this would shed light on their motives, the impact of standardization, and the difficulties encountered.

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