Participatory Design for the Development of Inclusive Educational Technologies: A Systematic Review

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Abstract*—Computer technology offers huge potential for assisting People with Disabilities (PwD), whether in daily activities, rehabilitation, or educational processes. However, we observed in literature that High Assistive Technologies (HATs) must be customized for each PwD, since a technology that works for one does not always work for another. In this scenario, the Participatory Design (PD) approach proves adequately to produce customized HATs for PwD teaching and learning. Using PD approach, this paper discusses the adaptation of PD4CAT method, including the educational stakeholders in the process. This adaptation is based on results of the Systematic Review, from which derive methods, technics and technologies to support the development of educational technologies for PwD, including the user from the very beginning of the design process. The method was validated by a case study that involved a child with cerebral palsy, caregivers, therapists and educators. Therefore, an educational assistive technology was developed to support the child in the literacy process. It's intended, this way, to enable that HATS in educational context, as on the Computer Science and Engineering learning, can be developed in a participatory way and including educators on the design process, in order to facilitate the PwD learning in several knowledge areas.

***Keywords*—participatory design; development; educational technology; high assistive technology; people with disability**

I. Introduction

Computer technology offers huge potential for assisting People with Disabilities (PwD), whether in daily activities, rehabilitation, or educational processes. However, we found that these technologies – High Assistive Technologies (HATs) – must be customized for each PwD, since a technology that works for one does not always work for another. Specifically, in order to aid inclusion of PwD in the educational field, humane reception, technological adjustment and system customization become necessary for reducing limitations. In order for teaching strategies to be accessed by each individual seeking significant learning, we must promote the customization of processes, including technology.

In this scenario, the Participatory Design (PD) [11] approach proves to adequately produce customized HATs for PwD teaching and learning processes. This approach allows for the inclusion of PwD and other customized HAT users, who act as co-designers in producing a technological solution.

Participatory Design offers techniques that favor designer-user dialogue in order to collaboratively build technology. A method PD4CAT (Participatory Design for Assistive Technology) was created in order to develop HAT applications. It is based on the conventional structure of an iterative software development cycle, in which prototypes are successively refined based on analytical and empiric assessment of its qualities [13]. Even though it foresees the involvement of various stakeholders, PD4CAT was proposed in a context in which educators were not involved in participatory design.

Using PD approach, this paper discusses the adaptation of the PD4CAT method [13] by including the educational stakeholder in processes. This adaptation is based on analysis of the results identified in the Systematic Review (SR), from which methods, techniques and technologies are derived in order to support the development of educational technologies for PwD, by including the user from the very beginning of the design process.

II. Methodology

The methodology employed in this research started with Systematic Review, divided into three stages (Planning, Operating and Result Extraction). The benefit of this type of literature review includes systemizing search means, by seeking to identify, assess and interpret the available research in relation to a specific subject, as well as identifying the existing gaps, in order to collaborate with scientific development.

The SR protocol was established in the planning stage, in which we define search sources, keywords, and inclusion and exclusion criteria, as well as the research questions presented below:

- Which methods have been applied in the partipatory design process of educational technologies for PwD?

- Which techniques have been applied in the participatory design process of educational technologies for PwD?
- Which technologies and tools have been applied to include PwD in creating educational technologies?

In order to search for answers to these research questions, search strings were combined using keywords defined in the SR protocol and the research was conducted by searching varying the IEEE, ACM and Springer databases

In the Operating stage of the research, we considered the primary studies published in the last 10 years, in order to find more recent approaches. However, we also considered classic concepts found in studies published in previous years.

Still in the SR Operating stage, we considered two important stages: i) preliminary selection, which consisted of analyzing titles and summaries of each work and ii) final selection, which consisted of analyzing complete texts of articles included in the preliminary selection stage.

The studies included in and excluded from the SR were defined according to the inclusion and exclusion criteria established in the SR protocol.

Figure 1 presents a flowchart, based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [6], which it synthesizes the SR operating stage.

Out of 131 works found during the SR conduction stage, 36 works were selected on the preliminary selection stage and 10 works were included on the final selection stage, the ones who seek to answer the referred research question. These articles sought to answer the research questions posed in the SR protocol.

The flowchart shown in Fig. 1 seeks to present, using quantitative data, the SR process that starts with the initial identification stage of studies obtained from database searches and ends with the final selection of articles included in the data extraction stage.

In the result extraction stage, selected studies were analyzed in order to understand the techniques, methods and technologies that have been developed in the investigated field.

From each study included in the final selection, relevant aspects were extracted for research, such as: type of disability, application context, inclusion strategies and participatory design, and, finally, tools that were employed. These aspects will be presented in Section III.

The PD4CAT was then presented and discussed in light of these results.

From the SR results, it was then possible to include in the PD4CAT method the possibility to support the developing educational technologies for PwD, thus broadening its application in education and in different fields of knowledge, including engineering and computer sciences.

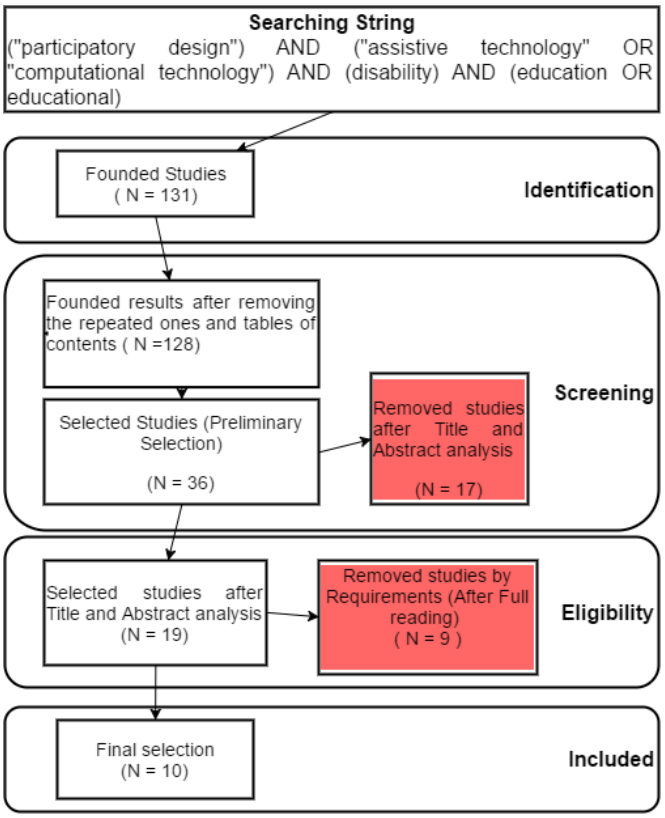

Fig. 1. Distribution of studies included and excluded from Systematic Review

III. Results of Systematic Review

The following paragraphs present a brief synthesis of each one of the 10 articles that were analyzed. It is worth emphasizing that seven out of ten articles employed classic PD concepts and another three developed an optimized PD method in developing tools for PwD.

Two sections were created, the first pointing towards the goals of each article included in the SR and the second section presenting a SR analysis regarding the techniques applied, the methods perfected and the technology developed.

A. Purposes of the selected articles

The following summaries address the aims of the studies through the PD method, whether using the classic or optimized method, and its applicability. However, the scope of the study addresses different types of disability and age groups; in other words, it is not restricted to just one disability or specific age group.

A study conducted in children by De Leo et al. [3] presents the development of a software to facilitate communication and improve social habits of children with autism spectrum disorder (ASD). The results of the experiments were positive and the conclusion was that developing healthcare-related technological equipment for a group with children with ASD encounters difficulties. In order to overcome these obstacles, the authors propose that the building process include the participation of teachers, who act as representatives of the children.

Still in the context of development of children with ASD, a study by Fage et al. [5] presents the project CS+, whose goal is to provide an activity scheme in order to support children with autism (ASD) during the inclusion of these in integrated classrooms. An app was created from the PD method: CS+ (Classroom Schedule + Efficacy). The group was divided in two, one using CS+ in the classroom and the other using only verbal communication. The results of this experiment were proof of the app's efficacy, as verbal communication of children with ASD equipped with the app improved compared to those who did not use the app. Therefore, the authors concluded that all children who employed the app showed significant improvement in social behavior and adaptability. With the use of participatory design in this project, it was possible to obtain more information about each student's illness.

A study by Harrison et al. [7], with the assistance and support of pupils and their tutors, seeks to delineate and develop an adaptable and inclusive educational tool that can be available online, specifically restoring the needs of young adults with serious disabilities and learning disorders (SLD).

The virtual learning environment (VLE) proposed by Harrison was a technology developed with the intention of being an exclusive virtual environment adaptable to each type, for computers only, and addressing only the disabilities of the target group of the study; i.e., the VLE does not apply to people with visual impairment or who are blind. Finally, the study concludes that the VLE may encourage greater learning capacity among those users and an "anytime and anywhere" access. It is a tool with accessible Learning Objects and tools that are personalized for each user, as long as the user belongs to the study's target group.

Another study with autistic children was conducted by Hirano et al, [9]. The aim of the study is to show how the use of visual scheme tools vSKED, developed to help children with autism, can affect their behavior and learning activities. Additionally, it concludes that the project contributed to reducing anxiety and improving classroom interaction and individual communication. However, these tools afford great burden to the teachers, who spend a lot of time and energy creating, giving support, and employing these tools. Furthermore, there is a lack of functionality in current tools, such as the interactive and automatic data registration.

There are also studies that developed technologies from cognitive disabilities that are popularly unconsidered, albeit scientifically proven, called learning disorders (LD).

In this same context, the study conducted by Vinumol et al. [15] reveals a prototype called INTERACTIVE TEXT BOOK for children with learning disabilities/difficulties (LD). This study used a user-centered approach and applied technology to aid in the learning process of children with disabilities/difficulties, thereby reducing learning obstacles and difficulties. Technologies such as Tesseract OCR and Augmented Reality were necessary for developing the tool. Analytical results demonstrated that children could learn to memorize and obtain knowledge through a simple process and a user-friendly interface. Finally, the study concluded that, in order to overcome the barriers of a children with LD, an educational technology that is capable of simulating their interests is needed to guarantee an efficient learning session.

A study conducted by Drigas al. [4] aims to create a tool to ensure easy access and navigation to students with some type of visual impairment in web content, in addition to integrating them socially. Regarding the technical aspect, the authors presented a methodology that was defined in 3 stages and followed a model similar to participatory design. They thus developed a website using techniques such as principles of "Design for all" and "Universal Accessibility". However, the website that was built is now abandoned and outdated, even though it has greatly contributed to the creation of an educational and informative system available online that is adjusted for people with some type of visual impairment or who are blind.

Subsequent studies such as one by Kim [10], which concerns visual impairments (VI), aim to examine the use of multimedia formats and accessible tools in the field of education for teaching specific concepts, as well as analyze the adequacy of multimedia in student requirements with the aim of supplying knowledge of a certain subject. Kim developed a user interface design (UI) that helped students with visual impairment gain a better understanding of concepts such as heat and temperature. However, the inclusion of VI students must still be investigated.

A study by Nganjiet al. [12] presents a way of creating accessible learning means that is useful for children with disabilities. ONTODAPS, a VLE, was developed by following a disability-aware (DA) methodology after consulting students and users with disabilities. The ONTODAPS system was well received by students, who graded it 7.8 on the basis of 5 factors. The authors conclude that the proposed system allows users to access learning resources and thus are both easily accessible and user-friendly.

A study by Robles Bykbaev [14] also suggests another way of creating new assistive technologies (AT) to provide support in the education of children with disabilities in the first three levels in school. The model presented reveals a different way of building interactive tools, such as the creation of a step-by-step model (guide showing how to create a tool for special education) and also the creation of a flowchart. Thirty-one prototypes were successfully developed: 17 for cerebral palsy and 14 to provide assistance for hearing and visual disabilities.

A total of 25 prototypes are used in centers today, while 6 are still in a process of reengineering. The most relevant technologies were: a computer system for assisted teaching of deaf children who attend the second to third year of primary education; an educational system for people with cerebral palsy, based on Nintendo Wii control, Braille Calculator and Multisensory room "Snoezelen". The authors concluded that, with the development of these prototypes and its respective applications, children have shown improvement in learning and better access to educational programs.

Heylighenet al. [8] have a study worth citing that employs a different teaching technique, which indirectly affects PwD as it seeks to conduct a more detailed analysis of which lessons architecture students can learn in buildings they have visited with expert users in a field activity. In other words, which moral values were aggregated when mobilizing experiences of incapability in an informal lesson in architecture. Based on that experience, the study brought to light that fieldwork interaction contributed to intensify the development of policies/constructions for people with disabilities, thus also contributing to human variability in the psychological realm.

The related works were organized in Table I, so as to improve visualization of results and its relation to the investigated disability. It is notable that the items analyzed in the studies and summarized in Table I represent important characteristics concerning age group, stakeholders involved, disability, and whether final user participation is allowed. Based on this set of articles, it is evident that the research being conducted presents at least one inclusion strategy that allows participation of the final user throughout the whole process.

B. Analysis from Systematic Review

From analyzing Table II we can see that, regardless of the disability or method being used, the techniques used for applying the method and development of the technology (if it exists) are related; i.e., the techniques possess elements that allow for communication between the developer and researcher and the remaining actors involved, whether directly or indirectly.

We can also confirm that three auxiliary methods were developed based on fundamental PD traits. We can also observe that 38 different technologies were developed, all of hich had PD in common, and 32 of which originated from the method elaborated by Robles Bykbaev [14]. As for the methods employed and the respective articles that applied them, there are:

- Classic PD: [4], [5], [7], [8], [9], [10], [15];
- Design by Proxy PD: [3];
- Disability Aware: PD and user-centered principles [12];
- Supportive models for PD: PD with guidelines [14].

It becomes clear that there are diverse methods to provide educational assistive technologies for PwD.

As for the techniques employed, the three more commonly used in these SR studies are literature review, prototypes and questionnaires. These are strategies that are crucial to PD and are strongly related. As for the three least commonly used, these techniques include: principles, reengineering and fieldwork. Check the variety of techniques identified in studies in Figure 2.

Lastly, regarding the technologies developed, we will classify them by order of inclusion significance, according to data from Table II.

The Level of significance of inclusion addresses the level of importance, which had inclusion of the person with disability throughout the execution of the project. For better understanding:

- If it is possible to finish the project only with its caretaker/person responsible, then: Low;
- If the person with disability has been included in later stages, then: Medium;
- If the project is extremely dependent on PwD throughout the whole process, then: High.

TABLE I. MAIN CHARACTERISTICS OF SYSTEMATIC REVIEW WORKS

REFERENCES	**Items present on work**				
	DISABILITY	***Age Group***	***Inclusion Strategy***	***Allow the end user involvement***	***Stakeholders involved***
[3]	ASD	Children	X		Special Education teachers, therapists, parents and Developers
[4]	VI		X	X	Developers and blind individuals and Hellenic organization
[5]	ASD	Children	X	X	Developers, mainstream teachers, special education teachers and school aides
[7]	SLD	Young Adults	X	X	Developers, tutors and learners (end user)
[8]	MI		X	X	Teachers, Students and PwD
[9]	ASD	Children	X	X	Teachers, neuroscientists, autism specialists and parents
[10]	VI	Teenagers	X		Developers and Teachers
[12]	Multiples	17+	X	X	Developers and disabled students
[14]	Multiples	Children	X	X	Developers, teachers and end user
[15]	LD	Children	X	X	Children with Disabilities and Family and Classmates, Teachers of special educations and centers and therapy, Developers
Total	---	---	10	8	

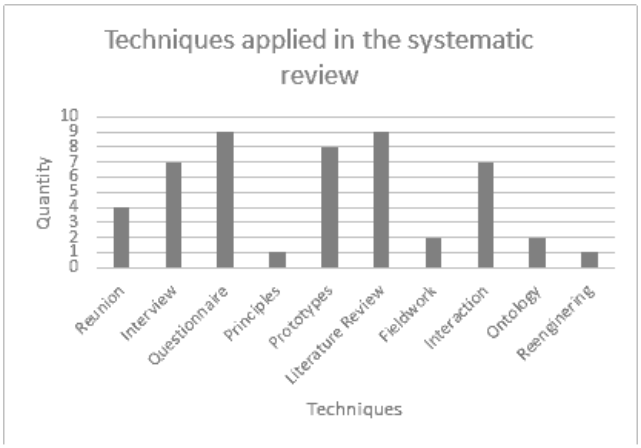

Fig. 2. Techniques applied in the systematic review (SR)

We noticed that the solutions developed in the studies found in SR link technology with a determined group of disabilities. When technology is developed in order to assist more than one disability, as can be observed in Table II, we can see that the methods being used were different from the classic PD. These discussions will allow us to analyze the PD4CAT and suggest its adequacy to the educational environment.

IV. PD4CAT ADAPTED TO EDUCATIONAL FIELD

It was then possible to include in the PD4CAT method, using the SR results, support in developing educational technologies for PwD. The PD4CAT method discussed in this article includes PwD as co-designers of the solution, along with other members of the multidisciplinary team. The method was verified by a case study that involved a six year-old child with cerebral palsy, caregivers, therapists and educators in the educational solution by participatory design. In this case study, an educational assistive technology was developed to support the child in learning how to read.

In light of the analyses of what other methods identified in the SR could contribute to PD, we believed it was viable to insert educators acting as stakeholders - co-designers in the PD4CAT method.

We can verify that including educators in the PD process is crucial for the design of personalized educational technologies, just as involving therapists and caretakers has been recognized for allowing inclusion of PwD throughout all the design cycle [17], thus vouching for PD principles, according to the PD4CAT proposal.

This possibility allows us to suggest a new version of PD4CAT.

A. About the adapted method

PD4CAT is a method based on the conventional structure of a development cycle of iterative software, in which prototypes are successively refined based on analytical and empirical assessment of its qualities, just like many user-centered design models, for instance [18] and [19], as well as the incremental model [20]. The original PD4CAT was published in [14].

It is composed of four stages: 1. Team composition; 2. Discovery of the solution; 3. Detailed specification of the solution; 4. Design of the solution. These stages occur with the support of two processes: accommodation process for PD and participatory assessment process. These stages were based on traditional models of software development; however there was a need for technical adaptations, in order to allow for the inclusion of PwD in PD practices so they

TABLE II. METHODS, TECHNICS AND TECHNOLOGIES APPLIED ON WORKS

REFERENCES	**Items present on work**				
	DISABILITY	**METHOD**	**TECHNIQUE**	**TECHNOLOGY**	**LEVEL OF INCLUSION**
3	ASD	PD and Designing by Proxy	reunions, interview, prototype	(Nameless) Smartphone solution	MEDIUM
4	VI	PD	Prototype, questionnaire and principles from Designing for All and Universal Accessibility	Multi-Purpose E-Environment Interface	MEDIUM
5	ASD	PD	Reunion, interview, questionnaire, prototype, interaction	Classroom Schedule+ (CS+)	HIGH
7	SLD	PD	prototype, questionnaire, interview	VLE (Virtual Learning Environment)	LOW
8	MI	PD	Interaction, questionnaire, interview, design, fieldwork/field experiment	--	HIGH
9	ASD	PD	Interaction, questionnaire, interview, prototype, literature review, fieldwork	vSked	HIGH
10	VI	PD	Reunion, questionnaire, Interaction and Literature review	--	HIGH
12	Multiples	Disability-aware	Ontology, interview, interaction, questionnaire, prototype	ONTODAPS	MEDIUM
14	Multiples	PD w/ supportive model for new tools	Literature review, Debate, prototype, reengineering, interaction, questionnaire	Braille Calculator, Multisensory room "Snoezelen" and others 29.	MEDIUM
15	LD	PD	Prototype with AR (Augmented Reality), interaction, interviews, questionnaire, ontology	AR based Interactive Text Book	MEDIUM
Total	---	13	12	38 (7+31)	

could act as co-designers in the personalization of solutions.

In this new PD4CAT version, such stages remain the same, even with the inclusion of the educator as a stakeholder. The possibility of using greater variety of PD techniques was broadened, however, as presented in Subsection C, which, according to SR results, are indicated for the educational field.

The accommodation process for PD does not directly affect the production of personalized technological solutions, but it gives support to other stages of the process, adapting the strategies used and generating the necessary artifacts for executing PD activities. The process of participatory assessment, which also provides support to all other stages of the method, is responsible for evaluating results obtained by the PD4CAT, both in relation to the design process and in relation to the results associated with the product under development.

B. Roles in the method

As defined in literature [20], the stakeholders in this process are the people who integrate the research study's multidisciplinary team and act as participatory designers through PD4CAT. These stakeholders may include managers of the health institution, PwD, therapists of PwD, caregivers, developers and specialists of specific domains.

Note that one of these stakeholders should act as a moderator in the PD practice. In this new PD4CAT version, and in order to generate educational HATs, the educators of PwD should be included in the PD process.

C. Goals of the PD4CAT stages and processes

The stages and processes of the new version of PD4CAT are presented below.

Stage 1 – Team composition – Seeks to establish a partnership with the rehabilitation institution and educational center, in order to define the people who will compose the team of participatory co-designers. This team is composed of therapists, educators, caregivers, and PwD. Ethical aspects of the research are addressed in this stage.

Accommodation process- Engenders the creation of strategies– personalized techniques- to include the stakeholders in the design process, thus acting as co-designers, throughout all subsequent stages of this method.

The therapists, in partnership with the educators, play a crucial role in suggesting strategies that include PwD in their educational HAT design. Caregivers may help particularly in the process of understanding and communicating with PwD. All stakeholders, with the exception of PwD, are involved in PD practices in each stage of the PD4CAT, thus seeking to obtain a PD experience in the respective stage. With this acquired experience, stakeholders become capable of creating a PD technique adapted for the inclusion of PwD.

Stage 2 – Discovery of solution – As in the viability study of classic engineering project processes, it analyzes the context of the PwD and their daily needs and therapeutic and educational requirements. As a result of this stage, the team indicates a HAT proposal that can assist PwD in the educational process.

Stage 3 – Detailed specification of the solution – Provides the details of all stakeholders regarding the functionalities of the solution, indicated in stage 2 by PD practices. At the end of this stage, we must obtain the necessary software requirements and physical accommodations for the solution. In order to do so, the therapists, educators, caregivers and PwD mush specify relevant details for the solution, while developers foment discussion and reflection about the computational solution suggested in stage 2.

Stage 4 – Solution design – The solution interface design is obtained, related to its functionalities, through PD practices with all the stakeholders.

Participatory Assessment Process – Seeks to evaluate results conceived in the design concerning the personalized solution and PD practices applied in the accommodation process throughout the remaining stages of the PD4CAT, regarding the effective inclusion of PwD. We also verify with stakeholders if the generated design has answered their expectations, also in relation to the usability attributions, so that it is possible to suggest improvements if necessary. This assessment also occurs after the solution is delivered for the final user employs it in their daily life, collecting feedback from the PwD and the caregiver through a diary that monitors the software, interviews, PwD observation using the software, etc.

Table III presents the techniques that have shown to be significant for the new version of the PD4CAT, granting more relevance to the SR methods that present a HIGH level of inclusion, since PD4CAT values the inclusion of PwD in all stages of the PD. According to Table III (techniques of original PD4CAT) many technique presented by the SR are already adopted by PD4CAT in its stages and processes.

TABLE III. STAGES, PROCESSES AND TECHNICS OF PD4CAT

PD4CAT STAGES/PROCESSES	TECHNIQUES OF ORIGINAL PD4CAT	TECHNIQUES POSSIBLY ADDED TO PD4CAT
1- Team composition	interview	Interaction, reunion
2 – Discovery of solution	interview, storyboard, literature review	interaction, reunion, fieldwork, reengeering
3 – Detailed specification of solution	interview, brainstorming, mockup, literature review	interaction, fieldwork, reengineering
4 - Design of solution	prototype, design, literature review, mockup, storyboard	interaction, reunion
Partipatory Assessment process	design, interview, questionnaire, prototype	reengineering, reunion, interaction, field experiment
Accommodation process	adapted interview, card sorting, prototype, storytelling, mockup	fieldwork, interaction, questionnaire

In addition to those, SR and comparative studies such as the ones we have done present some more ideas regarding techniques we believe have the potential to be added to the arsenal of techniques that could contribute to PD4CAT, as presented in Table III (techniques added to PD4CAT).

In the SR literature consulted, we did not identify techniques adapted to include PwD, such as the ones generated in the accommodation process of the PD4CAT. What we found regarding techniques for feeding the accommodation process were only preliminary suggestions of techniques for futures adaptations.

D. Case study

The PD4CAT method was verified by a case study that involved a six year-old child with cerebral palsy, caregivers, therapists and educators in the educational solution by participatory design. In this case study, an educational assistive technology was developed to support the child in learning how to read.

The child involved in this case study cannot read or write, does not speak and communicates in gestures, uses a wheelchair for larger distances, and presents the left hand as the most functional part of the body, uses it with dexterity and explores electronic devices intuitively.

The child's parents agreed and signed a free and clear consent form to include the participation of the child in the research, according to Brazilian ethical norms.

For developing educational and personalized HAT, the following techniques were adopted in the PD4CAT four stages and two processes, according to the SR and previous experiences with PD4CAT. These techniques were applied in the rehabilitation center and educational institution to which the child belongs.

- Stage 1 – Team composition: reunion, interview, interaction;
- Stage 2 – Discovery of solution: reunion, interview, interaction, storyboard;
- Stage 3 – Detailed specification of solution: interview, brainstorming, interaction;
- Stage 4 – Design of solution: prototype, interaction, design;
- Assessment process: reunion, interaction;
- Accommodation process: adapted interview, card sorting storytelling.

Considering the specificities of the case, we decided to incorporate the techniques of reunion and interaction. In the reunion, all stakeholders meet to discuss the problems and the design of the prototypes [5][10]. That technique is similar to brainstorming, previously adopted in PD4CAT. Therefore, the 2 techniques can be adopted together, in the most profitable stage of the solution design. As to the interaction, it is used to foster virtual communication among stakeholders, by means of the web or social-integration platforms [5][8][10]. In this case, a group was created in WhatsApp to discuss issues related to the study. Besides, in private conversation through this app, researchers and developers of the tool exchanged ideas and thoughts. The e-mail service was also used in the whole case study to exchange information and files.

We exemplify below one of the accommodation techniques of this case study in order to better demonstrate a technique adapted by stakeholders of the PD4CAT.

This technique is called "Adapted interview", and occurs after the accommodation process in Stage 2 – Discovery of solution.

Fig. 3. The child discovering the solution by the accommodation process

The focus of this technique is to enable children with verbal and mobile disability to express their particular needs and life styles, in order to visualize a personalized computational solution that will be of interest to their lives.

The child's mother, therapists and educators talk about the child, focusing on some questions previously planned by the stakeholders to stimulate the child to manifest, while the child listens to the discussion. The child's expressions are observed during the informal conversation. Stakeholders, with the exception of the child, promote interactions with the child, seeking to stimulate participation in the discussion. In order to provide assistance with the child's communication, yes or no questions are presented, a paper board, and some personal toys, including her mother cell phone. Figure 3 shows some of those moments. Therapists, educators and the mother help understand the child's expressions.

In all PD4CAT stages, the educators, in partnership with therapists and the PwD's mother played a crucial role in identifying the child's therapeutic and educational needs, as well as her insertion as co-designer in the PD4CAT stages.

The chosen techniques met the desired needs, ensuring the PD proposal, in which it is important that some learn with others, while collaboration mutually in the process, and express themselves freely.

We highlight that the PwD who managed to express herself, even with her limitation, especially through the adaptation of the chosen techniques and because of the accommodation process of the PD4CAT.

Beyond that, this case study was successful in helping the child read.

V. CONCLUSIONS

This study allowed us to check method and techniques that were useful to educator stakeholders, as well as technologies developed through participatory design. Based on these, the PD4CAT was adapted to the educational field.

We therefore intend to create opportunities for HATS in the educational context, useful to PwD, for example, in teaching engineering and computer science, which can be developed in a participatory manner and including educators in the design processes.

An interesting question to be perceived is that revealing the methods and HATS development techniques allows for transparency in software development. By knowing how they are developed, different stakeholders can take ownership and contribute to the processes of software engineering.

From the results obtained in this study, further experiments need to be conducted to check for possible limitations and improvements of the adapted method, expanding its application in education and in different fields of knowledge and learning levels.

In this initial study, the techniques identified by the SR have undergone initial studies of the applicability of PD4CAT. However, they need to be tested in further studies to verify the effective adherence to PD4CAT. Other techniques such as "reengineering" and "fieldwork" could not be tested at this point and require further investigation. With respect to the raised methods, these can be compared to PD4CAT, so as to enable further analysis, thus giving rise to new ideas.

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