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FROM AN INDIVIDUAL TO THE INSTITUTE: A CASE OF 'MULTI-USER CENTRIC CODESIGN' APPROACH IN DESIGNING SOLUTIONS FOR CHILDREN WITH SPECIAL NEEDS IN RESOURCE-CONSTRAINT SETTINGS

Kavyashree VENKATESH and Shakuntala ACHARYA
Indian Institute of Technology, Guwahati, India

ABSTRACT
Design of specialised products, such as assistive devices, for users with special needs, such as children with disability, requires a holistic design as well as pedagogical approach. The designer/engineer is encouraged to take a Problem-based Learning approach with the intent to develop 5 top skills identified for industry-readiness and in turn, aid in developing learning objectives for each skill based on the design experience, that will be invaluable for the designer/engineer for designing specialised solutions (assistive/customisable devices) for special user groups (children with special needs), by leveraging systemic collaborations with multiple users, beyond the solo primary user/beneficiary group. This paper presents, the adoption of the co-design approach with multi-users, beyond the primary users, involved in the rehabilitation of children with special needs, and reports the reflections and insights of designer/engineer on the required learning (objectives) to design such specialised products that employs co-design / multi-user centric design process. Presently, these learning objectives are being implemented in design project course to evaluate its impact on the 5 top skills as learning outcomes.

Keywords: Product design, engineering, learning objectives. co design, assistive devices

1 INTRODUCTION
Assistive devices (ADs) and technologies are highly specialised solutions, as they heavily rely on domain and experiential knowledge of experts and users, that an engineer or product designer may not possess. Along with user involvement, interdisciplinary and transdisciplinary research is inevitable for the design of assistive devices, products, and technologies [1]. It is multi-faceted; where the medical aspect, the design aspect, and the integration of the two, determine the extent of successful usage of these products [2]. The challenge of designing ADs for children with special needs is further compounded as the children, i.e., the primary users; are incapable of providing user needs and requirements, which are very critical in these devices [3,4]. Limitations related to language usage, literacy, and variation in cognitive development to communicate ideas can pose as a further hurdle in designing such solutions with children as co-design participants [5]. So, while designers and engineers have the innate ability to undertake the required research – secondary and primary, to define technical and market needs, they face difficulties in defining the user needs, as well as incorporating the user feedback, in spite of employing co-design, due to the above mentioned issues. Therefore, there is value in educating them on ; (i) identification and prioritisation/ categorisation of the multiple users involved in design of specialised medical devices for special needs groups, and (ii) the appropriate or potential of co-design, but extended so as to accommodate important users and expert individuals and institutions, such as, therapists, rehabilitation professionals and rehabilitation centres, who are capable of being sound design partners and custodians of the beneficiary or primary user, i.e., children with disability.
The Problem-based Learning (PBL) perspective, which is known to be fruitful in developing key skills in designers and engineers, such as, critical thinking, problem solving, communication, collaboration and self-learning [6], was employed to deliver a design-based project course with the development of these skills as learning outcome. A design exercise was undertaken, beginning with identification of

real-world problems faced by children with motor impairments and designing a customisable assistive device for them through co-design. During this exercise, it was empirically found that designers benefitted from adopting the multi-user centric approach, which extends co-design, from an individual, i.e., the primary user, to multiple users, i.e., the members and the institute.

2 BACKGROUND LITERATURE

New levels of expertise and interdisciplinary methods are required to incorporate appropriate levels of knowledge and skills from all stakeholders to develop ADs [1] and hence, a pedagogical intervention has value. ADs play a prominent role in the rehabilitation of people with disabilities, as using these along with available treatment procedures help people with disabilities achieve independent and dignified living [1]. Rehabilitation is crucial to enable the functional ability of children with motor impairment [7]. Evidence from the literature further emphasises that ADs are preferably customised to suit the local context, therapeutic requirements, and user environment [8,9] and that rehabilitation professionals/therapists look for means to customise these products to fit the patients. The therapy sessions (physiotherapy) and activities are vigorous and often uninteresting to children, however, employing ADs during these sessions can make them engrossed in the activities [2]. Along with the caregiver, the rehabilitation professionals/therapists are key stakeholders in the use phase of the ADs and may, in certain cases, also be users [7]. They are the main facilitators of ADs to end users/beneficiaries and implicitly influence the choice, adoption, and regular usage of ADs by the patients [10]. Their knowledge of functional implications, biological aspects, therapeutic requirements of disability, etc. is paramount in defining user needs for ADs [10], and they can also mitigate the circumstances during the design process due to their standing with the primary user, the child beneficiary. Therefore, they are not only secondary users, but also proxy for the primary user. However, while direct communication between designers and users helps in a better understanding of the problem domain and facilitates the elucidation of relevant design parameters within the design process [11], the engineers and designers are not educated in "how to" mitigate such special needs circumstances. Understanding the nuances of the use case and user environment for the design of ADs beckons the involvement of users and caregivers in defining the same, in turn, aiding the designer/engineer to incorporate social, emotional, and cultural aspects of user contexts [12]. In addition to this, factors like recruiting participants, especially children, and their caregivers in the entire design process and not just during the later stages of validation can be challenging for the design team. Further, building the connection with the caregivers and the children, time consumed during data collection, children's attention span during the process, and children's cooperation can be hurdles in the design process [12]. Thus, several learnings are required on the part of the designer/engineer to enable the design of ADs, that too for users with special needs.

In the instances where the experience and knowledge of the user on a specific domain becomes critical, the user participates in the design process as the co-designer. The products or interventions that have multiple users or require interactions between multiple users and require interdisciplinary expertise from multiple stakeholders, need the understanding of all the stakeholders, leading to a multi-user centred design approach [13]. These are characteristic of co-design, and while there is strong evidence from earlier works [2,3,10,13] regarding the adoption of this approach in the design of ADs, there exist lacunae in what capacities or the extent of involvement and role of various stakeholders in these approaches. Therefore, by extending the co-design approach to 'multi-user centric' enables the multi-users to partner in the design process, not only as experts and secondary users but also as proxies.

This holistic approach has been used as a learning environment to pursue the development of the 5 top skills (learning outcome) and in turn, identify the specific learning objectives required by designers and engineers for the design of ADs for special needs groups.

3 MULTI-USER CENTRIC CO-DESIGN PROCESS

The below presented design exercise undertaken as part of the 'Design-based project' course wherein the objective was to identify a 'wicked' problem and design a specialised solution for a special needs group. Based on the area of interest, the designer/engineer chose the design of a customisable assistive device in resource-constraint settings and explored multi-user centric design approach. This section describes the design process followed, and reports the reflections and insights of the team on the design as well as the learning outcomes of the design process ;

The design process began with the identification of a rehabilitation institute/centre to undertake a habitat study, through observation of therapy sessions. Training of hand skills was identified as a major opportunity area, upon corroboration with the rehabilitation professionals. A design aid for supporting hand skills training, involving the actions linked to “Touch”, “Rotate” and “Press” was arrived at on the basis of the therapeutic requirements of the children in the institution, with the key motive to increase the engagement and participation of the children during rigorous and repeated training sessions. A gamified approach in training these skills was conceptualised.

A ‘board game’ was devised which operated as follows: An auditory stimulus is triggered to indicate the child to begin the game. The child has to progress through the different junctures of the game, beginning from the “start” point up to, the “finish” point using these actions - touch, rotate, or press (Fig. 1a). There is a reinforcement in form of green light for every ‘expected action’ (either touch, rotate, or press) of the child as per the requirement of the game. The reinforcement light also acts as a guide to help the child move to the next stage in the playground. A simple prototype to establish the concept (Fig. 1b). was developed, using rapid prototyping techniques. Provision to include fixtures based on the specific needs of the children to enable customisation was also provided. Feedback on the concept and prototype, obtained from the rehabilitation professionals, established that the concept was usable, appealing to the children and was designed based on the local context and requirements of the children and the institute.

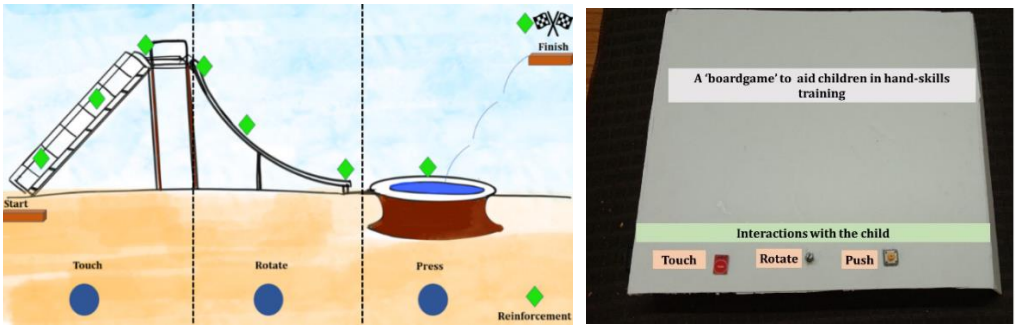

Figure 1. Finalised concept ((a): illustration of the concept, (b): embodiment of the board game

Leveraging the experience of the design team in this process, engagement of the multi-users for the co-design and development of assistive devices, may be described in 3 phases, as illustrated in Figure 2.

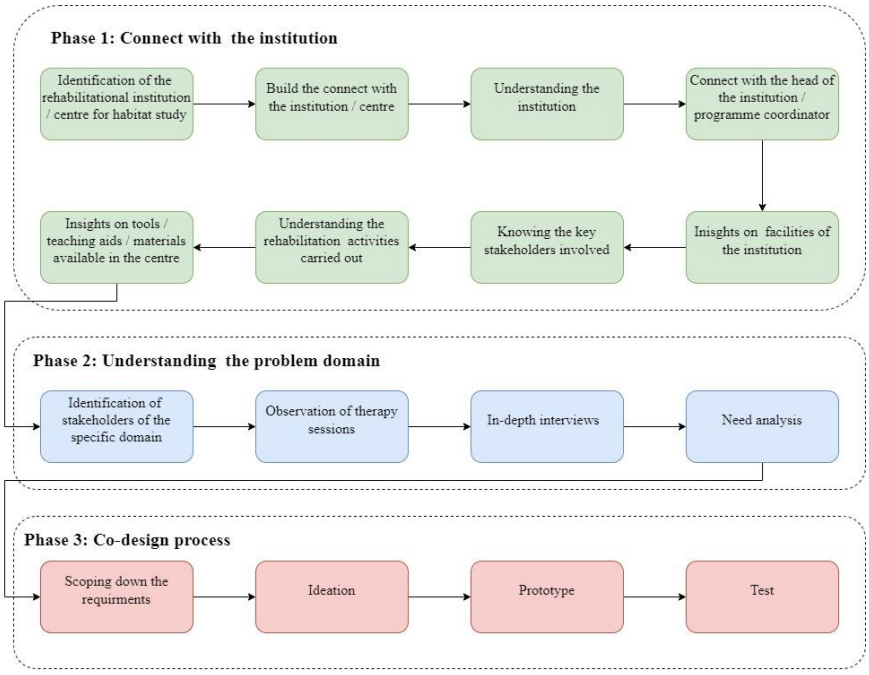

Figure 2. A diagrammatic process flow of ‘multi-user centric’ co-design approach

4 DISCUSSIONS

4.1 Reflections and Insights from the designers

Following are the reflections and insights of the design team on the multiple-user centric, co-design approach for design of a customisable assistive device for children with motor impairments;

- A key insight is that the rehabilitation institution/ centre, along with its physical and human resources, behaves as a one-stop solution for understanding the problem space and serves as an active ground for testing and iteration. It also saves time in the overall design process, helps build trust among the other stakeholders, and promotes easier acceptance and adoption of the designed intervention.
  - *"Interactions with the institute's program coordinator helped in knowing its functioning, facilities, activities undertaken, etc. Further discussions highlighted different stakeholders, involved in the institute, their roles, and responsibilities in the rehabilitation / therapeutic activities. This was better understood with the observation of therapy/training sessions, and familiarity with existing assistive devices and tools which aid in these sessions were also understood."*
  - *"Although the children are the direct beneficiaries of any assistive devices used during therapy sessions, the other stakeholders are users of these devices as well, and their needs, and ability to bridge and elucidate the needs of the children, is very critical in the successful adoption of assistive devices. This was clearly established during the observations and interaction sessions while designing the aid."*
- The evident insight was that, enabling the multi-users (rehabilitation professionals, caregivers, and the institute itself) in taking design decisions, encouraged them to convey their requirements as users and facilitators of assistive devices during sessions, which would not have been captured exclusively otherwise. Further, involving the multi-users, not just for the usability testing, but also at various stages including, but not limited to; elucidation of needs, understanding the problem space, generating technical requirements, scoping down the target, concept generation, prototyping, etc. resulted in a usable, user-friendly design solution, which is appropriate to the local context, as per the expert feedback obtained.
  - *"Adopting rapid prototyping tools and techniques helped in building proof-of-concepts to communicate ideas among the different users involved, and also, to include features that facilitated customisation."*
  - *"Another important learning was the mode of communication and exchange of ideas, and concepts between the design team and the other stakeholders. Real-life images and illustrations proved effective in communicating and exchanging ideas with non-designer partners (rehabilitation professionals, parents, etc.) in the process of co-design over sketch-based illustrations."*
  - *"Due to prompt involvement, quicker iteration cycles of prototyping could be undertaken, and multiple functional versions of the prototypes could be developed and tested with the users and proved to be better in comparison to testing of mock-ups or sketches."*
- A profound insight received was that the multi-users have a common understanding of the target audience. Beyond eliciting requirements and affirming the needs of children, feedback on the prototype from these multi-users proved to have high coherence. This paved the way for; exploring scenarios to extend the use of the same aid to other users or target groups and understanding new requirements from other groups within the same system.
  - *"In addition, exchanging ideas and expertise among different design participants, i.e., the designer/engineers and rehabilitation community, strengthened the collaboration which paved the path for future work between the same teams."*

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4.2 Learning objectives and outcomes

The design-based project, used as the learning environment for engineers and product designers in the area of design of specialised products, such as, assistive devices for special needs groups, helped identify the various challenges discussed above and in turn, below mentioned learning objectives pedagogical support to incorporate the top 5 skills for Problem-Based Learning.

The following learning objectives have been outlined and are presently being practically implemented in the project course;

- ***Critical Thinking:*** To engage with multi-users and at the instructional level, beyond the user/individual, so as to receive and develop critique and analytical take-always on the situation;

- ***Problem solving:*** To enable multi-users with design decisions and in the equitable role as co-designers and participants, beyond being experts, testers, and feedback providers;
- ***Communication:*** To visit frequently and observe sessions, and be involved in continuous conversation to analyse, evaluate as well as convey design intentions for being on the same page;
- ***Collaboration:*** To leverage institution to garner trust and to imbibe onus in each user type as design participant on behalf of the beneficiary, but also oneself as an important user;
- ***Self-learning:*** To lean on the expertise of expert users as well as one's primary research experience to learn about the design situation and participants, prior to as well as throughout the co-design process.

5 SUMMARY, CONCLUSIONS & FUTURE WORK

This paper explores the nuances of 'multi-user centric' co-design approach by engaging with multiple users, i.e., a rehabilitation institution/ centre and its professionals, to design a specialised solution as an assistive device for a special needs group, i.e., children with disability, more specifically, motor impairment. A customisable assistive device to train hand skills was conceptualised and a prototype to establish proof of concept was developed with participation of the multiple users. Feedback from them - institute programme coordinator, special educator, etc., on the overarching concept and initial prototype, indicated that the device could be extended to other target audiences as well. The reflections of the design team on various aspects of the design process, including challenges faced, and benefits of engaging with multi-users is presented in this work, based on which learning objectives are mapped to desired outcomes (top 5 skills) for engineers and product designers, so that they may leverage these in designing solutions for special needs and in turn, inculcate the desired skills of industry readiness. Presently, the set out learning objectives are being implemented in the design project course to evaluate its impact on learning outcomes and the quality of design outcomes, with the intent to develop a holistic pedagogical support.

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