ABSTRACT
Using our ongoing project SHRUG on exploring the use of simple, tangible and responsive feedback on post stroke rehabilitation, we wish to share some of the key aspects that impact the development of collaborative solutions to existing gaps in healthcare. We aim to emphasize the importance of defining the technology gaps, identifying the target users and building solutions using a user-centered design process through valid qualitative and quantitative research methods. Based on our collaboration, we will also highlight some of the challenges we encountered during this process and how we have been trying to address them. This includes our experiences in establishing and sustaining a research collaboration and keeping all stakeholders engaged.

Author Keywords
Stroke, Rehabilitation, Research collaboration.

ACM Classification Keywords

INTRODUCTION
Project SHRUG [1,2] was initiated to investigate the use of interactive technology principles to enhance the rehabilitation experience for post-stroke patients and the physiotherapists. The goals of the project and collaboration were formulated after conducting preliminary studies to identify the existing methods in rehabilitation of persons with physical impairments resulting from stroke-related conditions or ageing. Conducting such preliminary studies helped us appreciate and understand the nature and magnitude of the problem in Singapore where ageing is one of the major issues that has been receiving a lot of attention. It also provided us a context to formulate the goals of the project and to be able to communicate with the healthcare professionals with ease.

Through our preliminary studies, we observed that, exercise programs focusing on the rehabilitation of the shoulder are a common occurrence in rehabilitation as the shoulder can significantly improve the ability to perform Activities of Daily Living (ADL). ADL are a standard set of activities that gauge the patients' recovery process through rehabilitation after disability that may be caused by an event such as stroke. These programs commonly feature exercises that utilize both shoulders together such that the ‘strong’ shoulder is able to guide the ‘weak’ shoulder through the proper movements. In this paper, we refer to such programs and/or devices as exercisers. One such activity involves the placing of a wooden pole into a pair of horizontal hooks (Figure 1). This rehabilitation program may be carried out in a one-to-one session, within a group session, or away from medical supervision at home.

Figure 1: Existing shoulder exerciser at St Andrew’s Community Hospital.

While this shoulder exerciser is in fact effective, our informal observations at the rehabilitation ward of St. Andrew’s Community Hospital revealed some key major limitations faced by the patients and healthcare professionals. This helped us understand two perspectives to the problem. From the therapist’s perspective, the lack of feedback from the exercise devices requires therapists to constantly keep an eye on the patient and their exercises. This is a key limitation during a group session as commonly there are only a few therapists overlooking the process. This is also a major
limitation given the supply-demand of therapists and patients. In addition, this often results in the patient repeating erroneous actions until noticed by a therapist. Secondly, the lack of recording and storing specific activity information limits the ability of the doctors to look at the patient’s rehabilitation history in finer detail in order to customize the exercise programs. Furthermore, the therapists could not review the patients’ activities when they are performed away from the rehabilitation center. From the patient’s perspective, the above limitations resulted in the limited efficiency of the rehabilitation programs resulting in reduced motivation of the patients in carrying out their assigned programs. The exerciser being passive did not engage the patients thereby making it monotonous for the users. These preliminary studies helped us understand the current gap in shoulder rehabilitation of ageing persons/persons with stroke. With this understanding, we developed a prototype (Figure 2) to explore:

- The effectiveness of providing interactive and just-in-time feedback to the patients and therapists
- The effect of adding a gaming element to enhance the motivation of the patients.

**Figure 2:** The SHRUG Prototype. Hooks light up in green/red to indicate correct/incorrect placement of the pole on the platform.

**FORMING COLLABORATIONS**

One of the most important criteria to be considered before even initiations a collaboration is understanding the desired outcome. It is essential that the expected outcome be clearly defined in terms of the scope, individual goals and objectives as any differences or lack of concordance in the project may manifest itself throughout the period of the collaboration if this is not clearly understood and defined. This was addressed in the SHRUG project through preliminary studies and talks with the healthcare professionals from St. Andrews Community Hospital to get an understanding of the challenges in shoulder rehabilitation.

It was important to define the outcomes in terms of what users would be promised to receive. We had many rounds of discussions to decide if the primary goal of the collaboration is to create knowledge or to propose a tangible measured improvement in the quality of life of persons with a disease condition. This drove the type of solution – whether we propose to conceptualize something novel or make an improvement to an existing system. Given the nature of the problem, we agreed on improvising the existing exerciser to make it interactive but also propose something novel by gamifying the entire process through instant feedback to patients and creating performance data for the therapists. This opened up the possibility of generating publishable knowledge as well as developing a practical/useful solution for the hospital.

We started off with team of researchers from our end but, the team kept on changing as some researchers moved out of the university and some new researchers joined in. These changes in the team is one of the challenges we faced, having to re-establish relationships with our healthcare collaborators. Having well-documented project maps was helpful in helping the new members get in-sync with the project. However, this may also result in some changes in the proposal to cater to the new possibilities generated by the new researchers while familiarizing themselves through informal observations at the hospital.

**LESSONS LEARNED**

While forming collaborations involves a lot of understanding of issues and perspectives to problems and their impact, what is even more challenging, as illustrated in our project is maintaining these collaborations and managing conflicts. SHRUG was a predominantly participatory study with a user-centered design process and has been planned in two phases.

**Phase 1:** This involves (individually) introducing the SHRUG to the therapists; getting them to use it for 20 minutes and evaluation through focus group interviews and questionnaire to get feedback on the SHRUG device and suggestions for the potential modifications to the existing prototype.

**Phase 2:** This involves (individually) introducing the SHRUG to the patients by therapist; getting them to use it for the stipulated period by the therapist followed by an interview and focus group study to identify if using an interactive rehabilitation exerciser positively enhances the patient’s experience against a passive rehabilitation exerciser and if gamifying the rehabilitation procedure positively increases the patient’s motivation to continue the rehabilitation exercises.

We faced a few challenges while conducting the user studies (Fig. 3). Firstly, managing expectations during the studies has been one of the important issues that arose during phase 1. For example, while sharing the prototype of SHRUG and gathering feedback, there were often two different points of view from the researcher team and the healthcare team. As researchers, we aimed towards understanding how keeping the structure same but introducing an interactivity or gaming element
enhanced the rehabilitation process. The healthcare team sometimes showed a preference for automatic systems or virtual reality that required different degrees of involvement from their end. We have maintained the collaboration by frequent meetings at common platforms, interviews to understand their changing points of view as well as sharing our inputs and trying to establish common ground. It is common however, no matter how well defined the initial goals are, to change over the period of time.

Figure 3: Conducting Phase 1 studies with therapists

Secondly, while conducting user studies, especially focus group and semi-structured interviews with a wide range of healthcare professionals, it has also been a constant reminder for us to keep our language and tone simple and consistent without adding too much of technicality to it. Sharing the ideas, asking questions and understanding their opinions has been facilitated through interdisciplinary teams that understand multiple perspectives and can overcome the technical jargon. Similarly, conducting studies with patients also requires us to incorporate simple and effective language with as less ambiguity as possible.

Thirdly, owing to the strict regulation and ethical guidelines involved, it has been increasingly challenging to secure patients as participants for the study. Even with the support from the hospital, this has been a challenge. Therefore, we are currently looking at collaborating with other similar healthcare setups to avail participants.

Fourthly, the idea of an ideal solution undergoes change either from the healthcare team or the researcher team. In our case, there has been evolution of ideas on what is an ideal outcome for therapists and patients. Managing changes and the expectation that come with them has been a constant challenge. Understanding the roles and responsibilities of the team members, having project plans and milestones help to some extent in staying on the trajectory. Having said that, it is also imperative that the researcher team attends to the feedback from healthcare teams keeping in mind the latest trends in technology and innovating further on the solution. In our case, along with introducing an interactive and gaming element, we are currently looking towards building an additional shoulder exerciser to enhance the range of motion. While our desired outcome still remains constant, we are constantly innovating based on the healthcare and technology landscape.

FUTURE WORK
This is an ongoing study and we have completed phase 1 of the study, we are looking at forming other collaborations to recruit post-stroke patients in our user-centered design process as well as getting feedback from more healthcare professionals.

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REFERENCES
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