Design and Multi-disciplinarity : Co-creation in practice

Agnes Xue
Singapore Institute of Technology, SIT
Agnes.xue@singaporetech.edu.sg

Alfred Tan
Singapore Institute of Technology, SIT
Alfred.tan@singaporetech.edu.sg

Desmond Chong
Singapore Institute of Technology, SIT
Desmond.chong@singaporetech.edu.sg

Tim Xu
Singapore Institute of Technology, SIT
Tim.xu@singaporetech.edu.sg

Design and Multi-disciplinarity : Co-creation in practice

Abstract
In 2016, a multi-disciplinary faculty and student team consisting of Design, Engineering and Occupational Therapy disciplines from the Singapore Institute of Technology (SIT) collaborated with METTA Eldercare Centre (METTA) to re-design an arm skate meant for the rehabilitation of the upper limb. The objective of this project is to also increase the efficiency of the set up and removal of the arm skate, address the occupational needs and physiotherapy needs, and enhance the overall motivation level of the post-stroke clients[1] going through rehabilitation exercise. A multi-disciplinary approach that puts the user at the centre of the design process was used. To react in training reflective practitioners, institutions are now opening up to involving a real client who serves as an active participant throughout projects, be it non-credit bearing, to provide a real life design challenge, real-life parameters and real-time feedback. Finding the right level of depth for this project by choice, addressing quality and core discipline technical specificities proved to be a challenge given the constrained amount of time available as well as level of maturity of the students involved. In this situation, both non-design faculty and students were also offered the opportunity to learn about design thinking and benefited by sharpening their intellectual awareness by dealing with vague problems, making explicit analyses and comparisons of the paradigms by layering social, community and economic relevance. They have learnt to creatively package and communicate their projects not for grades but with the aim to affect the world-at-large – this arm skate project has enabled them to see their knowledge, skill, and talents at work in a real-life situation.

Introduction

The world around us is in a constant state of flux. Given that most experiences are governed by incremental shifts happening, imperceptibly, over very long periods of time, it is disorientating, and rare, for people to experience a sudden step-change to the environment. However, students now have to respond to fast-paced images, text and movement. They may have an immense amount of access to resources and it is always impressive when students go back to their lecturers after one week with a video fully-edited, Arduino-coded, 3D model mocked-up after learning via YouTube tutorials. The amount of exposure they have as well by overseas travel and exposure all helps them to learn more, have access to deeper insights, think and articulate themselves better.

The flip-side to all this access to information, opinions and viewpoints, is the paradox of choice. A lot of students are paralyzed in decision-making and caring too much about other's opinions of what success is, what happiness is, what the "right way" is. Being aware is a good thing, but an overload of information may get in the way of personal growth and progress from lack of action. Some generations before, people experienced similar concerns and worries as students do now back then, but theirs seem to be multiplied by the real-time opinions via social media in this buffet age we live in now. The rapid-fire exchange results in less time for reflection.

Educators must emphasize the power of looking by engaging students in meaningful activities that require interactions with the physical environment. This is critical if students are to extract true meaning from their surroundings. We may prepare students to respond to rapidly changing realities by using design skills to devise innovative and flexible solutions. Design does not occur in isolation but rather it is part of a larger process that is the result of the forces surrounding its manifestation. We will only begin to realize our full potential as a society if we tap into the usefulness of some of the design tools available and use their influence to shape our surroundings. Design-led innovation is the key to a stable economic future.

[1] The term client is often used interchangeably with the word patient. There is no official distinction from the two different terms as our industry partner and therapists interviewed in this project use either term or both.

In higher education there are calls for active learning experiences that place the student at the center of learning, rather than accept students as passive listeners (Boyer, 1990; Felder & Brent, 1996). Global economic, social, and environmental change has precipitated the need for integrated science, requiring collaborative efforts across organizations, institutions, and disciplines (Di Castri, 2000; Kates et al., 2001; Kostoff, 2002; Cash et al., 2003; Rayner, 2006; Welp et al., 2006). Universities have all begun to take a serious look at their research focus. The idea of students as partners, change agents, producers, and co-creators of their own learning has been the subject of increasing interest in recent years (Bovill et al., 2011; Carey, 2013; Dunne & Zandstra, 2011). Although this need has been recognized for a long while, effective, collaborative problem solving remains elusive (Rhoten, 2003). Co-creation of learning and teaching occurs when staff and students work collaboratively with one another to create components of curricula and/or pedagogical approaches. Emerging research demonstrates that students are a valuable and often unrealised resource in higher education (Gärdebo & Wiggberg, 2012) and that academic staff and students derive significant benefits from working collaboratively on teaching and learning (Nygaard et al., 2013). The investment in a balance for collaborative problem solving with the blending of teaching, community and research is something strongly embedded into the culture of the Singapore Institute of Technology, Singapore's newest applied learning university.

It is based on this ethos that a multi-disciplinary faculty and student team consisting of industrial design, Engineering and Occupational Therapy disciplines from the university collaborated with a volunteer and welfare organisation METTA healthcare provider (industry partner) to harness this interest of multi-disciplinarity collaborative problem solving and applied learning by extending it through the notions of design to help students and industry partner achieve the goals they already have in mind by co-creation.

Multi-disciplinarity describes situations in which several disciplines and different professional areas cooperate but remain unchanged. Sharing of diverse approaches to problem solving is of great value and while this allows each discipline to grow, the core remains the same. There are also extant literature discussing the benefits of co-creation and how to involve users. The disciplines discussed include those within and outside of the design fields.

This paper describes the experience of collaboration among students and faculty in order to develop a real-world project, and to reproduce as closely as possible, the team's integration for industry partners. We outline different roles each discipline played and design and co-creation being the broad concept that encompassed diverse approaches. The outcome show that by this framework of a multi-disciplinary effort and co-creation with users, it does not only meet the industry's initial expectations but also deliver unplanned outcomes. Contributions from this project are extremely relevant both from an academic and practical point of view. The ideas presented should be viewed as a collage of thoughts, which build on one another in the spirit of sharing so that we can begin the questioning and exploration that must come if we are to keep developing a dynamic discourse about applied learning, led by design, delivered by multi-disciplines.

Project Development

There is more and more voices for reform to empower individuals and communities receiving public services by involving them in the design and delivery of the services they use, and the opportunity to use the talents and assets within communities to support self-reliance and build resilience. At METTA Day Rehabilitation Centre for the Elderly or known as METTA Eldercare Centre in short, they service post-stroke clients by providing a range of rehabilitation exercises everyday. Stroke is a leading cause of adult disability. It is estimated that 80% of survivors of stroke experience upper limb dysfunction and that around 60% of patients with stroke will not regain full use of their arm; however, improved

motor rehabilitation is often possible even in the chronic phase of stroke. At least 500 repetitions per session are required to elicit the neuroplastic changes that underpin functional recovery. However, studies suggest that conventional rehabilitation falls short of this goal, with an average of 39 repetitions of active exercise activity per session during post-stroke upper limb therapy being reported.

Due to niche markets the diversity and variations of specific assistive devices are very limited. Most of the time, therapists have no choice but to use standard assistive products that approximate the users requirements as well as possible. Due to standardization most of the tools also lack esthetical beauty and brand the user with a product stigma. In the opposite case, the patient or therapist does not use the universal products but takes them as starting points to build his or her own personalized applications. In fact, Metta has been using its own improvised arm skate for the past fifteen years. Therapists there had wanted something more suited for the Asian clients they service but the in-house arm skate was literally a chopping board with four castor wheels and client's arm was strapped on using multiple velcro straps to hold it in place (see Figure 1).

Figure 1: The environment and make-shift arm skate

This project was aimed at a duration of one year, with the different disciplines participating to design a brand new user-friendly arm skate device. There were four faculty members, one design-trained researcher, and four student assistants in total working on this project. The initial discussion of this research project focused on the typical innovation development within the disciplines of engineering and rehabilitation. Within typical assistive technology development, teams still tend to have exclusively clinical and engineering background and the dominant culture is one of problem solving and cost-cutting which is especially so also for our industry partner. Innovation within these fields is mainly technological driven: it lacks the tools to deal with social complexity and emotional responses. However, because of the involvement of the design discipline, problems involving people with some health issues have a certain "wicked component" which demands an opportunity-driven approach based on empathical insights unleashing the power of people ideas.; requiring decision making, doing experiments, launching pilot programs, testing prototypes.

The understanding of design thinking was fundamental to this project, which reinforces there should be a disciplined process for creating technologically feasible, strategically viable and innovative solutions that is based on a clear understanding of meeting people's needs and desires. Design thinking is a process guided by the realization people do not always know exactly what they want, or use things the way they are supposed to. Hence, the project team members are no longer people who conduct the research 'on' participants, but researches 'with' participants. Each member becomes a learner and facilitator in a creative environment to co-create sustainable innovation in response to healthcare challenges. A stream of literature within the field of user co-creation in new product and

service development investigates when and how customers can innovate products and services that are as successful as those of technical specialists. Research compared the quality and commercial success of customer- versus professionally-ideated products and services to learn that customers can surpass a company's professionals (Kristensson et al., 2002; Kristensson et al., 2004; Magnusson, 2009; Poetz & Schreier, 2012).

The team reconvened and decided to forgo the traditional innovation project approach where it is aimed at particular pre-defined objectives. It was decided that as a co-creation project, it can change numerous times as they are subject to the interaction and collaboration among different stakeholders and members of the project team. A conceptual framework consisting of multiple dimensions such as collaboration, styles research types and interaction modes was used to guide the process (Figure 2). Points like inter-personal interaction, observation and the notion of social innovation was taken into consideration, in fact, research and project scoping were then played out as a little zoom-in and-out game. When we were in the field, the team would soak into the scenes and observe everything with an empty mind; when we had breaks or conversations, or we started decoding notes the next day, the team would step back and zoom out a little to question everything, including our own assumptions. This effort was not easy at the start but it certainly paid off and helped us discover many hidden insights.

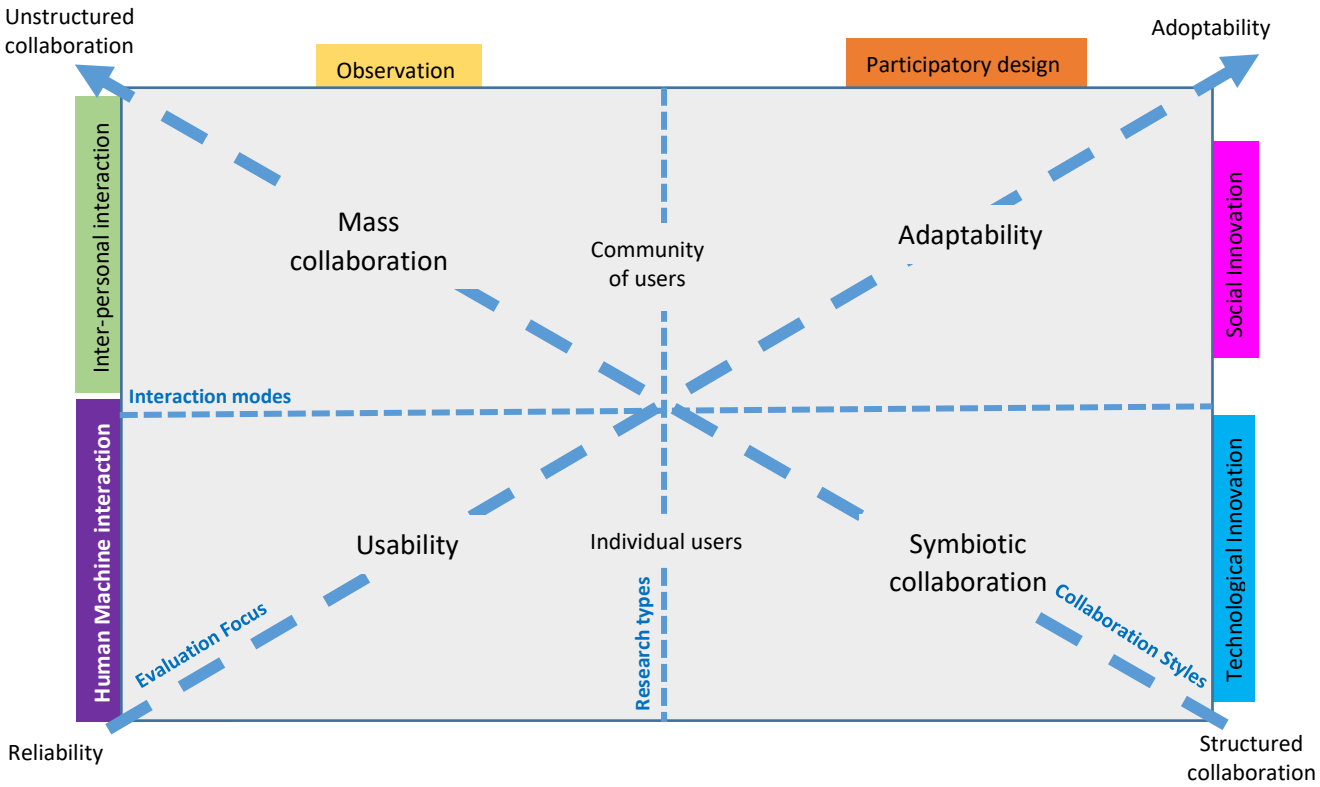

Figure 2: Conceptual Framework (Source: Adapted from Pallot et al., 2010)

The situation of the eldercare centre was somewhat similar to that of a childcare centre. At 7am, many are dropped off by their children who are already working adults, or they arrive in mini-buses together with their accompanying caregivers. By 8am, the centre was already crowded. When the team was out in the field, we followed therapists and clients from morning to evening and sketched out their rehabilitation journeys at every touch point. It was important to identify all the stakeholders and get a holistic view from different providers - in-house therapists, nurses, social workers, locum therapists in their various capacities. Then the team can design the products that work well with or even enhance the existing clinical workflow. It was liken to an immersion where it meant that every team member personally search for and meet stakeholders through a web of relationships, allowing us to be invited

by emerging circles as trusted members and makes the quest for unidentified clues a cumulative process characterized by small but continuous personal investments in networking. Communication can provide more transparency and thus creates a more robust relationship (Filieri, 2013; Fang et al., 2008) with a feeling of trust (Filieri, 2013; Ind et al., 2013)

The occupational therapist (OT) kept the overall goal of rehabilitation in mind: increasing independency and improving the quality of life. We have two groups of OT expertise in this project; faculty from the university and practitioners from METTA Eldercare centre. With their clinical background, they highlighted the medical constraints and possibilities for each individual client. Designing this arm skate device is like tailoring a suit – there are certain parameters and clients differ from each other. The better one knows the client, the better he will know what to customise. The quality of life is also defined as the degree to which a person enjoys the important possibilities of his or her life. The underlying premise of the therapists in helping clients to achieve better quality of life is to work out how one is connected to one's environment, and whether one achieves one's personal goals, hopes, and aspirations. Besides mapping any clinical constraints this exercise is also carried out on the client and on the caregivers in his environment. During the time the client is at the centre, the OT detects which type of assistive device the client needs to achieve his or her goals and by doing so he sets the starting point for the first iterations. In most cases the client and therapist have already physically hacked a universal assistive device which can be seen as a translation of a latent need or a hidden solution for the problem. The therapist evaluates every iteration through the behavior of the client.

We realized we deal with a somewhat 'wicked', 'fuzzy', or 'messy' problem here, and being a multi-disciplinary group with different points-of-views may have major difficulties figuring out what the users need and how to address these needs. First, it is very difficult to find objective and general indicators of what wellbeing is, and second, there really is no such thing as an 'ordinary user' when discussing radically different ideas. Traditional research falls short of this objective, and even some user-centered approaches lack the kind of user involvement that is needed to successfully address highly ambiguous problems. Hence, we took the approach that the client should be given the position of expert of his/her experience. In some cases when the client has difficulty with communicating his/her feedback verbally, the caretaker plays an important role as translator. Depending on the level of creativity they join the design process by expressing themselves in creating, using or adapting the assistive prototypes. Due to the iterative character of the methodology it is important that clients are mentally capable of building on past user experiences. The perceived value of a product is critical and determines the strategy of the following iterations. While reducing or eliminating the negative experiences and enhancing more positive values, the client also slowly adapts to his new assistive device. Although the nature of an everyday task could look simple, the context in which it takes place is always characterized by intricate interaction patterns between the user, his assistive appliance and the environment. Next to all the user experiences we try to map all these interactions in a user-product-environment model. Who are the stakeholders? What are their requirements? It is important to include the views and opinion of a range of stakeholders in the thinking and decision-making process. Co-design was used as a set of iterative techniques and approaches that puts users at its heart, working from their perspectives, engaging latent perceptions and emotional responses. With the combination of physical prototypes, led by design, it becomes a tangible pragmatic tool which continuously shifts between "what is needed?" and "what can be build?

While engineering aims for perfection, design values imperfection. The industrial designer in this project becomes the facilitator between the occupational therapist, the client and the engineer. The designers in the team continuously translates user-values and behavior into product properties. Our main job is to ideate and create tools/prototypes, which enables the occupational therapist to communicate on a physical level with his client (see Figure 3). In some "in vivo" test cases it is difficult

to obtain full-time engagement because the client is sometimes too fatigued or in pain to complete the user testing. Time is precious, so therefore we have to plan a scenario for each user-testing activity and avoid the fact that we may overload the client with too much information. The more varying and pronounced the concepts are, the quicker we get converging feedback from the user. When evaluating concepts, it is important to strive for the highest "level of measurement" by means of discovering the different aspects that are relevant for the user. In most cases aspects of iterated concepts will be perceived as "better", "good enough" or "worse" than the previous iterations. It is the task of the industrial designer to document this process and leave as many traces so that the user-community can harness the lessons learnt from the project.

Figure 3: Different phases of project development

Developing cross disciplinary understanding is the first step toward the truly multi-disciplinary perspective that is required for effective idea generation. In practice, idea generation involves a rather chaotic period of interaction between different participants as they learn about each other's perspectives and search for common ground. Design tools encourage participants to share their experiences and build on each other's ideas. The tools help to open up the design process to multiple stakeholders (Koskinen et al., 2011). At first, OT and engineering students came in with feelings of apprehension and uncertainty, but the design tools and artefacts gently ease them into the process.
A key element to practicing design thinking is then the discipline of prototyping and quick mock-ups. The designer and engineer were to be creative with the resources at hand, which leads in most cases up to a form of "hacking design". Product concepts are build and adapted out of re-used devices and basic materials which are available in the local context. Hacking methodologies have been particularly useful in developing nations for increasing the functionality of mobile phones and deploying the bicycle to serve other needs. But they are equally useful to address the needs of disabled people in Western culture as well. During this process the designer-engineer slowly shifts from experience prototyping to personal manufacturing. We kept ourselves informed of existing, new and emerging technologies, has an overview of available production processes. We adopted an incremental adaptation process which makes use of low-end prototyping techniques for translating user-values into product properties and vice versa. The project team was allowed to distil their concepts from research, insights, and experimentation without having to execute the centre's opinion as a consultancy service.

Adaptation Strategies

As the product development of the arm skate progresses, although the occupational needs and physiotherapy needs of users were addressed, the team figured out that it was equally important to enhance the overall motivation level of the post-stroke clients going through the repetitive movements during the rehabilitation exercise. To complement the improved physical arm skate, the additional novelty lies in the infusion of a virtual reality (VR) game to the arm-skate device to provide a rewarded, goal-directed task to upper limb rehabilitation via a reaching and scoring game. The clients receive auditory, visual, and numerical feedback during the game about their target goal and their current performance.

Virtual reality (VR) gaming is gaining more acceptance as a tool for increasing the intensity of stroke rehabilitation and has the potential to offer several advantages for motivating behaviour change for health and well-being. A recent Cochrane review indicates that VR can significantly improve arm function post-stroke. Intrinsic motivation for rehabilitation can be supported by incorporation of VR: competition (against the computer), challenging tasks, positive feedback, and knowledge of results can turn boring, repetitive reaching movements into fun, goal-directed motor skill learning. The team managed to produce a low-cost arm skate device using 3D printing, paired with a complementary non-immersive VR that align to the degree of patient impairment and computer gaming to encourage a wide range of point-to-point reaching movements.

A pilot study was subsequently conducted at the centre. Factors such as comfort, convenience, economy adaptation were well addressed by the proposed intervention. With the facilitation and guidance from the therapist, it also minimizes the "non-use" of their affected arms leading to better functional recovery towards independent living in the community. On another level, the identity and pleasurableness of the 'game therapy' appealed to the clients intrinsically as the arm skate is played with eagerness while it stimulates cognitive senses. Although one can play the game alone, it is engaging and can quickly became a conversational piece of the day with others, remarkably increasing social interaction. Another human aspect that we have been noticing while performing some observations is the increasing level of commitment that can be reached by including the clients in the design process. In the course of the co-creation process, clients revealed themselves as wanting to be future ambassadors of a personal assistive device they had provided feedback on.

Figure 4: Introducing gamification to rehabilitation therapy

Multidisciplinary teams are their best when evolving new strategies based on active research and the initial shared vision cannot be static; it must evolve as the team learns more about the problem of interest. There was a shared documentation repository set up for the students to note down any insights, gaps, or findings they found in the assimilation of the project. These evaluation reports were prepared using Google Docs forms. The researcher and lead faculty used these reports to monitor

progress and detect any potential delays in the teamwork process. There must be regular and ongoing evaluation of short-term results and reassessment of the vision. Project outcomes may or may not be precisely what was originally envisioned as the process of collaboration itself may change the problem definition in unanticipated and potentially interesting ways. This can best be accomplished if team members are apprised of others' progress such that sketch models or conceptual models are constantly updated. Achieving this level of performance requires focus, commitment, and good management. Figure 5 shows the process taken in how this project was developed.

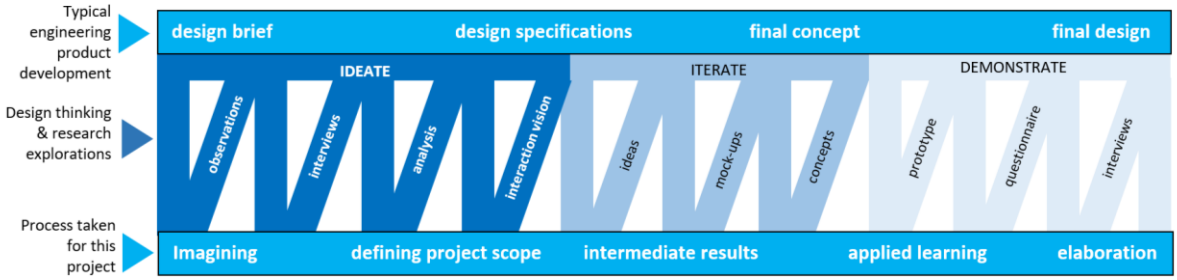

Figure 5: Project Approach and Process (Source: Adapted from Hepworth et al., 2016)

Discussion and Learning Points

The work here presented a hint of how some organization of actual engineering projects could look like and this is nicely rolled out as collaborative multidisciplinary learning through an out-of-classroom setting for these undergraduates. When students take authentic responsibility for the educational process, they shift from being passive recipients or consumers to being active agents; at the same time, they shift from merely completing learning tasks to developing a meta-cognitive awareness about what is being learned (Baxter-Magolda 2006; Cook-Sather et al., 2014). That shift fundamentally alters the student role, prompting a related reorientation for academic staff from being disciplinary content experts to also being facilitators of learning and shared enquiry. Some scholars suggest that "...in co-production, power is seen to be shared, which might be too challenging for students" (Little & Williams 2010, p.117). Indeed, finding the right level of depth for this project by choice, addressing quality and core discipline technical specificities proved to be a challenge given the constrained amount of time available as well as level of maturity of the students involved.

No doubt, faculty sometimes may under-estimate student abilities to contribute meaningfully (Bovill, 2014) and interpret student experiences as a deficit rather than an asset in the collaboration (Felten & Bauman, 2013). While faculty need to be aware that change can be worthwhile and have confidence in their ability to bring about the necessary innovations with appropriate support, students also need to be made aware of the benefits of trying new approaches to learning and that their confidence needs to be gradually built in order to overcome any potential resistance (Errington, 2001). Hence, when design thinking was used and taught to these students, it was mentioned to them that they need to see it more than just a method. As soon as it becomes a mindset to them, it builds up their creative confidence. Developing opportunities for faculty and students to discuss ideas or reflect on experiences of co-creation, can foster motivation by articulating visions of the possible (Goldsmith & Gervacio, 2011).

Multi-disciplinary learning activity through design approaches is best approached through a small group of two to five students, albeit faculty as well. Cooperative group behavior, size dependent, is required to complete tasks and the team members are individually responsible for their own as well as the group's progress. The shared documentation, research material repository and discussion is useful to help students become self-directed learners who internalize specific topics from different

subjects, programmes and courses with their own interests, and has been considered as an easy alternative to promote active learning, not only in this project but in other areas.

Student feedback collected stated that this project has helped them become more aware of the needs in the affected community and they enjoyed the experience during their participation. Looking back, they felt they made a positive difference to the organisation and wider ecosystem. The students found ways to apply what they had learnt from their core modules, from being discerning in searching and selecting supporting literature to applying theory and skills in the project. They were most fascinated with the various disciplines involved in the project, with everyone coming together to brainstorm and offer ideas, review the progress and decide on the next steps. The period of learning and seeing how psychology, design, engineering, and therapy can come together seamlessly was an eye-opener and this multi-disciplinary collaborative effort demonstrated endless possibilities for breeding innovation. The key difference in this project is that learning was indeed fundamental to co-creation in practice. Hence with this understanding of learning to be used to inform construction of environments and interactions conducive to effective collaboration (Mostert et al., 2007).

The advantages of active and cooperative learning have been well documented with a positive student attitude towards the subject and learning as the most consistent outcome (Millis & Cottell, 1998). Other outcomes include higher academic achievement, increased comprehension, retention and transference of learning, and development of higher level thinking skills (Felder & Brent, 1996; Johnson et al., 2000; Johnson et al., 1994). Cooperative learning has also been found to promote greater productivity, to generate new ideas or creative solutions, and increase student ability of social perspective taking (Cuseo, 1992; Lord, 2001).

Critical thinking is another outcome of this project. The students have demonstrated a relationship between commitment to the project and critical thinking, particularly in regard to weighting evidence, determining the validity of data-based generalizations or conclusions, and distinguishing between weak and strong arguments (Pascarella & Terezini, 1991, 2005). These findings extend to both traditional college students and adult learners (Klassen, 1983–1984). If students are adept at thinking critically, it will be second nature to them in gathering, analyzing, synthesizing, and assessing information, as well as sharpen their sensitivity in identifying misinformation, disinformation, prejudice, and one-sided monological argumentation (De Costa, 1986).

Last but not least, social relationships among team members are critical to the success of multi-disciplinary co-creation as seen here. Any group consists of individuals with differing characteristics. Learning to interact well despite those differences takes time and can be affected by the presence or absence of group processes that structure group formation, performance, and dissolution (Levine & Moreland, 2004). The foundations for group learning are dialog and the adoption of a set of relational practices that create a social structure, both of which provide opportunities for the construction of shared meaning (Boreham & Morgan, 2004). A group learns to collaborate by engaging in collaboration, the social action itself providing an opportunity for learning how to interact (Cook & Brown, 1999).

Conclusion

The experience has been very satisfactory for students and faculty, who have participated with enthusiasm due to the exit of the well-distributed work and updated communication. The quality of the developed project has dramatically improved work productivity of the healthcare workers due to the integration of the results provided by the different team members. Although measuring the success of such an effort can be subjective, from qualitative records, instructor experience and student feedback indicated that participant expectations were met or exceeded. Students analysed, reasoned,

discussed and decided on the solutions that their team mates kept suggesting until completion of the project. This project has enabled students to approach a problem from four different points of view and mould them to the opinions of the other contributions from different subjects. Such out-of-the-classroom discussion enabled rapid improvements in the students' ability to conceptualise and provided them the chance to improve knowledge in other areas of interest.

The success of this model of design-infused multi-disciplinary co-creation in practice has paved the way for more conversations between the university and other healthcare operators. Organisations from the hospitality, social and service sectors have also approached the university wanting to better understand this framework used which has proven to enrich education outcomes to deliver more sustainable and scalable applications for industry.

References

Baxter Magolda, M. B. (2006). Intellectual development in the college years, *Change*, *38*(3), 50–54.

Boreham, N., & Morgan, C. (2004). A sociocultural analysis of organizational learning. *Oxford Review of Education, 30*(3), 307–325.

Bovill, C. (2014). An investigation of co-created curricula within higher education in the UK, Ireland and the USA. *Innovations in Education and Teaching International, 51* (1), 15–25.

Bovill, C., Cook-Sather, A. & Felten, P. (2011). Students as co-creators of teaching approaches, course design and curricula: implications for academic developers. *International Journal for Academic Development, 16* (2), 133–145.

Boyer, E. (1990). *Scholarship Reconsidered: Priorities of the Professoriate*. New York: The Carnegie Foundation for the Advancement of Teaching.

Carey, P. (2013). Student as co-producer in a marketised higher education system: a case study of students' experience of participation in curriculum design. *Innovations in Education and Teaching International, 50* (3), 250–260.

Cash, D. W., Clark,W.C., Alcock, F., Disckson,N.M., Eckley, N., Guston, D.H., Jager, J. & Mitchell, R.B. (2003) Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences, 100*(14), 8086–8091.

Cook, S. D. N., & Brown, J.S. (1999). Bridging epistemologies: the generative dance between organizational knowledge and organizational knowing. *Organization Science 10*(4), 381–400.

Cook-Sather, A., Bovill, C. & Felten, P. (2014). *Engaging students as partners in learning and teaching: a guide for faculty*. San Francisco: Jossey-Bass.

Cuseo, J. (1992). Cooperative Learning Vs. Small Group Discussions and Group Projects: The Critical Differences, *Cooperative Learning and College Teaching, 2*(3), 5–10.

De Costa, E. M. (1986). Metacognition and higher order thinking: An interdisciplinary approach to critical thinking in the humanities. *Proceedings of the Annual Conference of the International Society for Individualized Instruction, USA, 15*, 2–15.

Di Castri, F. (2000). Ecology in a context of economic globalization. *BioScience, 50*(4), 321– 332.

Dunne, E. & Zandstra, R. (2011). *Students as change agents: new ways of engaging with learning and teaching in higher education*. Bristol: ESCalate Higher Education Academy Subject Centre for Education / University of Exeter. http://escalate.ac.uk/8064 Accessed 7th August 2014.

Errington, E. (2001). The influence of teacher beliefs on flexible learning innovation in traditional university settings. In F. Lockwood and A. Gooley (Eds.), *Innovation in open and distance learning. Successful development of online and web-based learning* (pp. 27–37). London: Routledge.

Fang, E., Palmatier, R.W. & Evans, K.R. (2008). Influence of customer participation on creating and sharing of new product value. Journal of the Academy of Marketing Science, *36*(3), 322- 336.

Felder, R. M. & Brent, R. (1996) Navigating the Bumpy Road to Student-Centered Instruction, C*ollege Teaching, 44*(Spring): 43–7.

Felten, P. & Bauman, H-D. (2013). Reframing diversity and student engagement: lessons from deaf-gain. In E. Dunne & D. Owen (Eds.) *Student engagement handbook: practice in higher education* (pp. 367–378). Bingley: Emerald.
Filieri, R. (2013). Consumer co-creation and new product development: a case study in the food Industry. *Marketing Intelligence and Planning, 13*(1), 40-53.
Gärdebo, J. & Wiggberg, M. (2012). Importance of student participation in future academia, In J. Gärdebo & M. Wiggberg (Eds.) *Students, the university's unspent resource: revolutionising higher education using active student participation*, (pp. 7–14). Pedagogical Development Report 12. Uppsala Universitet.
Goldsmith, M. & Gervacio, N. (2011). Radical equality: a dialogue on building a partnership – and a program – through a cross-campus collaboration. *Teaching and Learning Together in Higher Education*: Spring (3) Article IV. http://teachingandlearningtogether.blogs.brynmawr.edu/archived-issues/may-issue/radical-equality Accessed 28 November 2013.
Hepworth, J., Mulder, I. & Kleinsmann, M. (2016). Design for Liveability: Connecting Local Stakeholders as Co-creative Partnerships. *Fifth Service Design and Innovation Conference*, May 24-26, 2016, Copenhagen SV.
Ind, N., & Coates, N. (2013). The meanings of co-creation. *European Business Review, 25*(1), 86–95. https://doi.org/10.1108/09555341311287754
Johnson, D., Johnson, R. & Stanne, M. B. (2000). Cooperative Learning Methods: A Meta-Analysis:, co-operation.org/pages/cl-methods.html
Johnson, R. & Johnson, D. (1994). An Overview of Cooperative Learning, In J. Thousand, A.Villa & A. Nevin (eds) *Creativity and Collaborative Learning*. Baltimore: Brookes Press.
Kates, R. W., Clark, J.S., Corell, R., Hall, J.M., Jaeger, C.C., Lowe, I., McCarthy, J.J., Schellnhuber, H.J., Bolin, B., Dickson, N.M., Faucheux, S., Gallopin, G.C., Grubler, A., Huntley, B., Jager, J., Jodha, N.S., Kasperson, R.E., Mabogunje, A., Matson, P.A., Mooney, H.A., Moore, B. III, O'Riordan, T. & Svedin U. (2001) Environment and development: sustainability science. Science 292(5517):641–642.
Klassen, P. (1983–1984). Changes in personal orientation and critical thinking among adults returning to school through weekend college: An alternative evaluation. *Innovative Higher Education, 8*, 55–67.
Koskinen, I., Zimmerman, J., Binder, T., Redstrom, J., & Wensveen, S. (2011). *Design research through practice: From the lab, field, and showroom*. Elsevier.
Kostoff, R. (2002) Overcoming specialization. *BioScience 52*(10), 937–941.
Kristensson, P., Magnusson, P.R. & Matthing, J. (2002). Users as a hidden resource for creativity: Findings from an experimental study on user involvement. *Creativity and innovation management, 11*(1), 55-61.
Kristensson, P., Gustafsson, A. & Archer, T. (2004). Harnessing the creative potential among users. *Journal of Product Innovation Management, 21*(1), 4- 14.
Levine, J. M., and Moreland, R.L (2004). Collaboration: the social context of theory development. *Personality and Social Psychology Review, 8*(2), 164–172.
Little, B. & Williams, R. (2010). Students' roles in maintaining quality and in enhancing learning - is there a tension? *Quality in Higher Education, 16*(2), 115–127.
Lord, T. R. (2001). 101 Reasons for Using Cooperative Learning in Biology Teaching. *The Chronicle of Higher Education, 63*(1), 30–38.
Magnusson, P. R. (2009). Exploring the contributions of involving ordinary users in ideation of technology-based services. J*ournal of Product Innovation Management, 26(*5), 578-93.
Millis, B. J. & Cottell, P. G., JR. (1998). Cooperative Learning for Higher Education Faculty. Phoenix, AZ: Oryx Press.
Mostert, E., Pahl-Wostl, C., Rees, Y., Searle,B., Tàbara, D. & Tippett, J. (2007). Social learning in European river-basin management: barriers and fostering mechanisms from 10 river basins. *Ecology and Society, 12*(1), 19. Retrieved from http://www.ecologyandsociety.org/vol12/iss1/art19/.

Nygaard, C., Brand, S., Bartholomew, P. & Millard, L. (Eds.) (2013). *Student engagement: identity, motivation and community*. Faringdon: Libri Publishing.
Pallot, M., Trousse, B., Senach, B., Scapin. D. (2010). Living Lab Research Landscape: From User Centred Design and User Experience towards User Cocreation. First European Summer School "Living Labs", Aug 2010, Paris, France. <inria-00612632>
Pascarella, E., & Terenzini, P. (1991). *How college affects students*. San Francisco: Jossey-Bass.
Pascarella, E., & Terenzini, P. (2005). *How college affects students (Vol. 2): A third decade of research*. San Francisco: Jossey-Bass.
Poetz, M. K. & Schreier, M. (2012). The value of crowdsourcing: Can users really compete with professionals in generating new product ideas? *Journal of Product Innovation Management, 29*(2), 245-56.
Rayner, S. (2006). Editorial: what drives environmental policy? *Global Environmental Change, 17*, 4–6.
Rhoten, D. (2003). *Final report: a multi-method analysis of the social and technical conditions for interdisciplinary collaboration*. The Hybrid Vigor Institute, San Francisco, California, USA.
Welp, M., de la Vega-Leinert, A., Stoll- Kleemann, S. & Jaeger, C.C. (2006). Science-based stakeholder dialogues: theories and tools. *Global Environmental Change, 16*, 170–181.