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REFLECTIONS ON AN INDUSTRIAL DESIGN CURRICULUM PARADIGM SHIFT FROM MATERIAL PRODUCTION TO BEHAVIOUR CHANGE BY PRACTICE BASED ON A CASE STUDY

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ABSTRACT
This article narrates on work towards a new industrial design curriculum launched in 2016. The makeover promoted transitioning from traditional design education focused on both, industrial age manufacturing and first-generation Bloom's taxonomy, to recent expressions of new product development and innovation driven by constructionism and social constructivism. It integrates design research, heuristics, human-centred design, human-computer interaction, participatory design, user experience, STEAM (science, technology, engineering, arts and design, and mathematics) and CDIO (conceiving, designing, implementing and operating) frameworks. The new approach upgraded expected final outcomes from concept proposal to proving practically how solutions work, operate and their likelihood for user adoption. A water conservation project for a household serves as metaphor of that shift from material production to behaviour change with a third-generation activity theory and artefact mediation analysis. Designers and users participated as co-designers in an organisational and design intervention to improve sustainability awareness and performance. Water is a premium commodity because its scarcity. Research showed the most likely influence to change habit in a family came from their shared construction of knowledge based on their interaction. Instead of applying normative measures that were often seen as penalty. Design as persuasion was also essential for confirming habit change. Results made the project a students' benchmark because it's working prototype as unique value proposition and minimum viable product with prospect for user adoption and industry take up for manufacturing. The project also evidenced favourable and disparaging steps in the process of new curriculum implementation and redefinition of design as value adding.

Keywords: Activity Theory, CDIO, Curriculum Development, Human-Centred Design, Participatory Action Research, STEAM

1 INTRODUCTION

Our university required the makeover of a traditional industrial design curriculum. Design education experienced many changes since its previous reformulation more than a decade before. The course was still greatly based on a first-generation Bloom's taxonomy model that ran by preconditioning behaviour to fit learning objectives. A transmission teaching model delivered restricted 3D CAD software operational skills, model crafting and some aesthetic flair. A concept of students as containers that must be filled up with knowledge before they become creative showed limited application of the taxonomy as well. Students rarely escaped from a transactional relationship with the lecturer. That started with recalling information as per knowledge provided in an isolated unit, to later develop towards an evaluation stage set to demonstrate acquisition of predetermined technical skill. Design research and human-centred methodology units were positioned in the final semester when students were about to graduate. A university effort to promote a second-generation Bloom's taxonomy fell short since the course still suffered previous implementation legacy. Within this scenario, replacing a final evaluation stage by a creating one was welcomed. However, course history reduced cognitive and meta-cognitive potential as students learning was limited by what a silo unit taught at its foundational remembering stage.

Importantly, the course missed delivering on recent design education progress, such as, new product development (NPD), constructionism and social constructivism innovation driven methodologies that realised users were no longer consumers but discerning prosumers that needed inclusion in the design process. It was needed to bridge discipline's historical gap to integrate design research, heuristics, human-centred design (HCD), human-computer interaction (HCI), participatory design (PD) and user experience (UX). STEAM (science, technology, engineering, arts and design, mathematics) principles supported participants who worked with CDIO (conceiving, designing, implementing and operating) framework. The new approach went beyond considering a project as finished at proposal stage and pursued to validate it by proving practically how it works, operates and whether user adoption is probable. A water conservation project for a household serves as metaphor of need to shift industrial design focus from material production to behaviour mediation. Water is increasingly becoming premium commodity because its scarcity in Australia. User participation showed as most likely to influence a family through social construction of knowledge. Instead of applying normative top down energy and water control mechanisms that were perceived as penalty, restriction and often abandoned. The project evolved to a unique value proposition (UVP) with a working prototype as a minimum viable product (MVP) with likelihood for user adoption and industry take up for manufacturing.

2 PROBLEM STATEMENT

Industrial design is a more than one hundred years old discipline that grew from craftsmanship to trade and reached a professional status tightly knitted with the industrial age. As such, it served manufacturing and main input-output economy forces that depended in optimising and streamlining production. Efficiency cemented designer's position as product experts who appealed potential buyers with their aesthetic flair. Good looks created new consumer markets that were nurtured into needing basic mechanical and motorised artefacts that might simplify everyday living and give satisfaction. However, problems arose for discipline expertise when consumers became discerning users capable to shift from one type of product and provider to the next by swiping right (meaning I like) or left (meaning I do not like) within a phone app. Increasingly from the turn of the new century, industrial design productivity and role has fallen at the mercy of relationships with customers that might last as long as a Tinder match.

Globalisation added new challenges. Typically, industrial design runs on long time cycles of ideation, conceptualisation, development, production, transport and delivery that cannot compare with fast pace of changes in user behaviour and interest. The design problem has become complex and it is not easy for designers and producers to get to know who those users are. It is difficult to compete when they must bid for attention, obtain manufacturing projects and reach multiple markets internationally. For instance, in Australia, statistics showed two decades decrease in national manufacturing to below 6.8% of GDP by 2013 with forecast to decrease further below 5% by year 2025. Users also find more difficult to grasp what reality is and what is available that is useful. A market overloaded with a multitude of information and products is a contributing factor to confusion about what are the foundational human principles that should be maintained and nurtured. With this prism, sustainability as a concept becomes a critical factor not only for humanity concerning climate change but also a directional north for industrial design's survival in a knowledge-based and digital economy.

There is currently a difference between benchmark design education institutions and others trying to catch up with changes in society and technology. The former smaller group has generally shown continuous progress and exemplary vision. The larger latter group often must figure out how to break away from conservative models, jump the gap between tradition and modernity that is created by historical and administrative burdens, and show enough value adding to stay competitive, build a good reputation and have a valid say in the field. Both groups represent polar extremes. However, the value of this paper is to invite to problem solve new scenarios of knowledge that challenge their capacity and role in education and society equally. For example, a new breed of users capable of producing new knowledge and products according to their own aims and means. They have entered the design field with the force of entrepreneurship, crowd funding and hacking. They use technology that serves a purpose instead of being forced to design and manufacture because need to move investment out in the form of assets and stock in warehouses. Certainly, technology does not seem to be as much of a problem anymore as it is the behaviour, values and culture that support and relate to it. Therefore, both extremes of design education should consider:

1. How should design expertise change from designer-centred focus in relation to discerning users?

2. How should design education change from replicating expertise as teacher-centred transmission to transformational student-centred learning that keeps to reality presented by final users?
3. Is material production the main means for industrial design survival in a digital era?
4. Is it possible to find a new sustainable north for design education, expertise, students and users amongst the confusion of modern life and technology?
5. If so, what can be the new methods that can help improve industrial design curriculum chances?

3 METHODOLOGY

Modelling a new curriculum for industrial design in our school of Computing, Engineering and Mathematics required a new approach to normal curriculum design. The institution was a traditional teaching university based on behavioural preconditioning following Bloom's taxonomy. This framework was further limited by conventional discipline, course and unit expertise characterised by teacher-centred delivery. Whereas, modern design education was human/user-centred as the means to contextualise, consult and prototype solutions through practice. Student and academic forums were held over three years. Participants were nurtured to build capacity from their own insight, imagination and foresight. Eight curriculum advisors, industry experts and an external advisory committee contributed. Small exemplars with participants were developed that later developed into assessments and units to apply as lessons learnt into larger curriculum change. Among them, several honours projects were used as exemplars for lower level units to set a new direction for the course. The water conservation case study showed in this paper serves as a metaphor of the change that also students experienced.

An important realisation for curriculum change was that design artefacts were not only physical products but also abstract simulations that represented mental and conceptual models. Prototyping progression from low fidelity (Lo-Fi) to high fidelity (Hi-Fi) and high-resolution models were representation of semiotic, socio-cultural and historical arguments in a line of activity that helped social construction of knowledge. Therefore, design learning activity worked towards upgrading from old-style model crafting to more recent situated project-based learning. Emblematically, Papert [1], [2, 3] pragmatic constructionism in relation to but distinguishing from social constructivism via collaborative learning-by-making and learning-through-playing. Essential to creativity, students were enabled to independently play and pivot by hacking, constructing and reconstructing in a tinkering process of building design as new knowledge artefacts.

Curriculum was inverted from skills and theory acquisition before research and creativity to developing from design research by practice and co-design with users first that developed artefacts for particular purpose and people [4]. An "only way to learn swimming is by jumping into the water" approach helped developing design value. That relied on openly identified, discussed and accepted knowledge that had specific history, culture, people status and available technology. Students built a fresh discourse that helped overcoming predisposed influences through applied research and tinkering.

Third generation cultural-historical activity theory (3GCHAT) and activity systems analysis (ASA) were fundamental to explain change as it ensued instead of the way it was hypothesised traditionally. Activity theory asks the right questions to figure out complex real-life problems rather than providing ready-made answers. Like modern design, research on user activity crosses boundaries among disciplines, media and networks to find answers and prototype solutions. That border crossing makes Cartesian dualisms insufficient. Design subject (observer) and object (person or thing observed), are directly affected by mediating activities and tools that connects them and are indirectly influenced by circumstances in the form of rules, community and division of labour in a process of knowledge production [5-12].

4 RESULTS AND DISCUSSION

Students and academics were invited to take a new role of listening to users instead of directing them from the high ground of expertise. The designer became the apprentice of an active user who was an expert and master of his/her own life and needs. Through the practice of making knowledge together, there was a double activity carried by mediating artefacts that helped getting to know the other while getting to know yourself. That was progressively materialised into design artefacts that the final user evaluated. As example, the water conservation and awareness project followed a similar process. It was clear the topic was typical of modern wicked problems that required a new approach. Sustainability and climate change are popular topics that capture people's attention and concern.

Drinking quality water is a highly valued resource since it is difficult to find alternative sources for it besides rain water. Increasingly, improvement in its management and usage are becoming high priority in Australia because the country's naturally dry climate and low annual rainfall. Water conservation is especially critical in times of drought and water shortage. It is part of a system that depends on preservation based on day to day usage and household activities in times of abundance as well. However, strategies and technology available often fail because they are not adopted or implemented well.

Consultation, participation and observation with user groups made student and supervisors realise that standard implementation of design solutions in a household (central manual or automatic digital management) followed the pattern of parental control and financial penalty in the form of water bills. This rather reactionary measure did not help all members of a household to create sustainability awareness and responsibility. Parents usually had a back-end control and punished excess use. Children had difficulty grasping meaning and value of water conservation as it was an asset taken for granted in Australia. Often family relations were stressed by water measures and micromanagement after novelty about sustainability awareness wore off and the practice was abandoned. Differently, it was observed it would be life changing if design intervention occurred at the point of behavioural formation when it happens through daily familiar practice. An undervalued and still greatly unexploited area was the daily ritual of bathing that parent/guardian and child share as opportunity for increased experiential learning through play.

Project findings and design iterations led to a working minimum value product (MVP) and system solution closer to test deployment following three user focus groups. The first was about listening and learning who the users were, their daily whereabouts, externalised activities and expressions that were recorded through thick descriptions and later coded into transcripts from visual, written, and observational annotations. The second was about participation with users in relation to developing mental prototypes and receiving feedback in several conceptual models. Attention was dedicated to modes of persuasion as ways of creating habits through play and instils water sustainability principles while bathing. Again, descriptions and transcripts helped to confirm patterns of conduct that helped fine tuning design direction. A final interaction with users was meant to test a final Hi-Fi working prototype ready for evaluation. Parents and guardians mentioned small toddlers became active participants when interacting with the switched on physical-digital device that connected to the tap. The device activated a game that measured water flow and temperature. It transformed bathing time into learning through play activity that taught sustainability principles based on mathematic counting, animal and sea creatures that had to be saved from water scarcity or flooding, so to speak. Several sounds (onomatopoeic, music) and visual (graphics, push buttons, small video animations) signifiers helped on basic literacy and to set values and timing for the activity. Toddlers became time controllers of the activity and started lecturing about the importance of water use. Parents also commented they usually dreaded bathing time as they were time poor or tired at the end of the day. Instead they now found bathing was a surprising opportunity for family bonding and learning through play (Fig. 1).

Figure 1. Water conservation project exemplar

The value of this exemplar to the new industrial design curriculum is that both treated expert and non-expert as participants on a common activity of constructionism and social construction of knowledge.

Designer, parent or guardian and toddler (as final beneficiary) related at the same level. Likewise, students were promoted to junior/researcher at same level with a lecturer/supervisor (e.g. guide or moderator) and other users of design artefacts (e.g. toddler, other students). This allowed for a customised approach that gave purpose and meaning to participants and allow them to grow and own design learning progressively within their own context and circumstances. Crucially, the process adapted Engeström [9] based on figuring out a four knowledge contradictions cycle process that started with introspection of participants' histories, and iterated through contextualisation, empirical analysis, modelling and consolidation of new practice that STEAM and CDIO did not cover. This was important in our university since the cohort is very diverse. Statistically, students come from any of more than 100 ethnicities. 62% are first in a family at university, 39% speak a different language at home, and 27.9% is from low socio-economic status [13]. Digitalisation, industrialisation and declining education standards add extra pressures. OECD Programme for International Student Assessment (PISA) and Australian National Assessment Programme - Literacy and Numeracy (NAPLAN) data shows decrease of STEM skills coming from high-school regardless of high or low performers. This when 75% of the fastest growing occupations require STEM skills [14, 15].

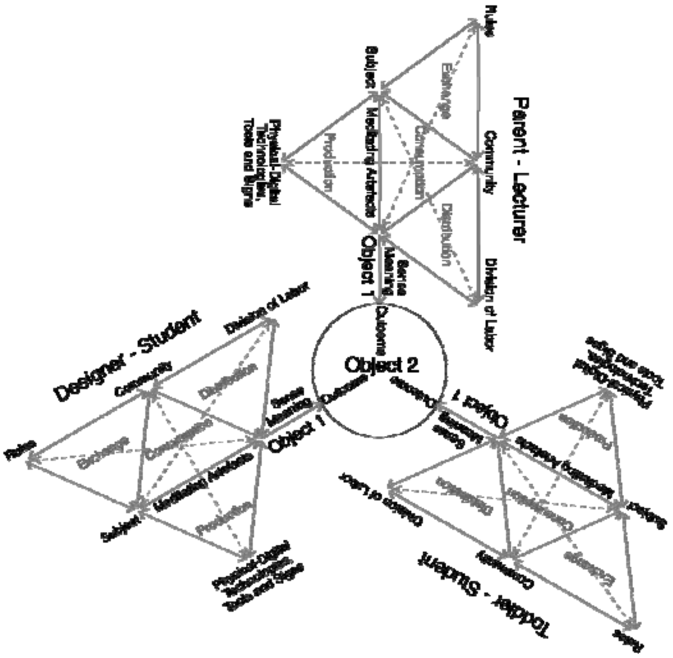

Figure 2. 3GCHAT- ASA model adapted from Engeström [9]

Learning customisation and ownership were critical for good results in projects. Focus on activity for over technical skill acquisition materialised in higher level design artefacts as students were driven by the thirst of making meaning. They had a purpose when using technology and that showed in extra dedication to present finished and working models after implementation of CDIO initiative. Students were also open to curriculum reformulation since they noticed difference between course and their everyday experience. Differently, several academics progressed through their own process of change. Some saw no need for it initially. Then, they proposed changing back curriculum to artistic illustration. Later to increase a technical engineering approach (3D CAD drafting). Both echoed national shortcoming concerning translation of education investment to innovation when thinking teaching is about transmitting operational skills instead of building new knowledge [16]. Academics driving change believed the course had to catch up and modernise as greater challenges are coming to test education in the form of design and algorithms, bioengineering, cybernetic intelligence, computer sciences, cultural studies, HCI, ICT, UX, HCD and 4.0 industrial revolution [17-19].

5 CONCLUSION

This paper demonstrated some basic principles that can enable dynamic changes in design education. Their strength is more transcendental than cutting-edge equipment procured based on a good business case and students modelling (e.g. machinery, workshops and 3D prototyping lab with large arrays from low to high resolution printing and materials). Participants broke away from traditional designer expert and passive consumer dualities with a dynamic based on dialogue between a designer/apprentice and an active user/master as the one who is expert on his/her life. Reflection made participants realise their experiences and articulate them. The process liberated students from traditional boundaries marked by hard manufacturing. They redefined design success from production and replication to meaningful relations that are built socially by activity, persuasion and interaction between humans and artefacts and among artefacts. Surprisingly, several academics had more difficulty than students adapting to change. The latter often improved quickly regardless of upbringing and socio-economic level. Often, expertise builds walls of isolation in institutions if experts keep to limited scope or slow upgrade. Regardless of position among benchmark innovators or laggards' extremes, industrial design education challenge today is whether it can overcome increasing changes forcing to abandon the comfort zone of technology and production and adopt learning that does not have easy or preconfigured answers. The time for technology for technology's sake is meaningless if it is not coupled with participatory and social construction of knowledge. A new curriculum cannot start by trying to implement specific technology a priority. Instead, it should be driven by insight and foresights on what will the profession be soon. Yes, some leading courses in Australia have already changed names (e.g. innovation, integrated product design). However, changing names still does not tackle the definitional, etymological, meaningful and procedural need to re-contextualise industrial design in a new reality of human and artificial intelligence 4.0 industrial revolutions, and the reversal of fortunes of globalisation where industrialised countries may no longer hold economic balance, power, and soon, the innovation edge.

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