THE INTEGRATION OF DESIGN PARAMETERS AND THE ESTABLISHMENT OF CONSTRAINT AND PRIORITY FOR INNOVATION

Roderick Walden and Kees Dorst
School of Design, Faculty of Design Architecture and Building, University of Technology, Sydney.
roderick.walden@uts.edu.au, kees.dorst@uts.edu.au

ABSTRACT:

This paper will present a new model for setting constraints and priority for contextualising innovation and iteration events during the course of new design development. It achieves this by establishing and dynamically integrating three parameter fields deemed critical to project success, setting the scope of innovation opportunity more broadly yet more strategically to enable productive reframing of open-ended design tasks. It is proposed that contemporary design practice requires a means of establishing criteria and enabling short feedback loops for high quality innovations to result. The integrated parameter model presented in this paper seeks to support these objectives by rationalising the context of the innovation developed, determining the impact of pursuit of that innovation on associated parameters and providing a focus for connecting with various support for productive and timely feedback on ideas.

Keywords : **integration, design parameters, innovation, constraints**

1. INTRODUCTION

Development of the model follows research into the application of typology models of self-initiated product design in educational settings to support entrepreneurial innovation (Walden & Kokotovich, 2012) and is supported by research into the self-exploratory approach to problem framing in DesignArt (Leitner, Innelle, & Yauner, 2013) that determined that a linear string of actions is purpose built according to the project and that no typical process applies. Research into the connection between innovation and the integration of multi-disciplinary teams in complex design, manufacturing and technical industries (Liu, 2011; Smulders & Bakker, 2012) also propose models of design practice that clearly divert away from the traditionally linear, hierarchical and stage-gate processes with a new focus on strategy and the need to facilitate and manage communication of ideas. Considering design education, Goldschmidt and Rogers (2013) found that undergraduate students responded to a design brief by first proposing a physical object (product) regardless of their discipline of study and did not follow a linear process. The study also showed that open-ended design tasks coupled with time constraints requires flexibility in methodological prescription. These findings further confirm the findings from Cross (2007) that the more ill-defined a problem is, the more readily designers propose solution concepts. Expert designers utilise strategies and knowledge (Popovic, 2004) to innovate, though for students fixation remains an issue for design education as does managing the less then steady progression of students towards a level of competency (Lawson & Dorst, 2009). This, particularly given designs expanded scope from products to systems and services that must address the new open and complex problems (Dorst, 2011) of today's society. In design education these factors represent a paradox as the generation of too many alternatives is an equally ill-effective strategy (Fricke, 1996). Yet the ever-widening scope of the problems that design projects should now consider makes determining the lens through which criteria and iteration of solution concepts might be challenged, very difficult. The integrated parameter model proposed is aimed at supporting design and design education by providing way of examining the contextual extend and prioritisation of innovation attached to solution concepts to determine whether to pursue that direction, adjust its emphasis or reframe the problem completely, while containing the scope of viable opportunity.

2. A BASIS IN SELF-INITIATED PRODUCT DESIGN

Previous research presented on self-initiated product design (Walden & Kokotovich, 2012) will be used here to provide the basis for demonstrating the integrated parameter model, proposed as a means of identifying the priority and constraints for innovation in product design projects. The reason typologies of self-initiated product design are an appropriate basis is that in self-initiated design, a foundational requirement for the commercialisation capability of self-initiated product designs is that they are both novel and open-ended. Beyond perception, the novelty attached to these designs must be registrable or patentable in some form and that means they must be innovative. This paper is concerned with priority and constraint decision-making in the pursuit of innovation. A more in-depth description of the development of the typologies of self-initiated product design is available in Walden and Kokotovich, 2012 however a brief overview of the background research follows.

2.1 SELF-INITIATED PRODUCT DESIGN

Self-initiated product design refers to product design projects conducted by practicing, professional designers that have been initiated without client request and are motivated by the designers own aspirations. The background research involved conducting semi-structured interviews with Sydney based, professional industrial designers. The interview included an intervention where designers were also asked to draw their design processes. Each interview followed a common procedure:

a) Please describe an example of recent client work.
b) Please draw your design process[1] for working with clients.
c) Please describe one (or two) examples of recent self-initiated design work.
d) Please draw your self-initiated design process.

Interviews were approximately 45 minutes in total length. Interview data was transcribed and reviewed using thematic analysis. The results of the analysis revealed that for self-initiated design projects designers use three forms of background knowledge - domain specific knowledge, strategic knowledge and experiential knowledge (Popovic, 2004) - to rationalise the progress of the design project toward a final outcome. The reliance and consequently, the development of these knowledge areas through learning events serve to establish the nature of three criterions of self-initiated design, also identified through the data analysis. These are 1) novelty - the design idea must be innovative; 2) support network - the project requires a network of support people that the designer calls upon and 3) control - design projects of this type are motivated by aspirations (Lawson et al, 2003) often unachievable in client work; so the designer seeks to maintain a level of control over the design development. These elements combine in various arrangements during the course of the design project finally settling into one of three typologies; successful (Figure 1) - meaning that the product was commercialised and is available on the market, semi-successful - meaning limited production or unsuccessful - meaning that the design remains a concept and is trapped in development 'limbo'. The research finds that designers establish priorities and manage constraint to drive innovative self-initiated design. The research also strongly indicates that for a designer their design process for client work is different from their process for self-initiated design and that self-initiated design process is variable.

[1] Interviewees were encouraged to verbalise a description of process procedure during the drawing phase for both client projects and self-initiated design projects.

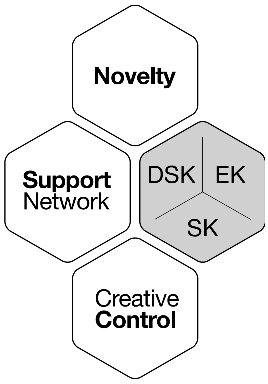

Figure 1: Typology of self-initiated product design developed by Walden (2012). The model represents the link between background knowledge - Domain Specific Knowledge (DSK), Experiential Knowledge (EK), Strategic Knowledge (SK) - and three criterions for self-initiated design projects.

3. THE SCOPE OF CONCERN

The integrated parameter model is a way of charting the priority concern and it's consequential impact on associated factors between the ideation phase, where a desired function for a novel concept is established; and the embodiment phase, where the actual function for the same novel concept is determined.

4. THE NATURE OF PRIORITIES AND CONSTRAINTS

In the examination of the interview data, it is evident that during the course of the product design development, the designer prioritises certain aspects of the project. An increased emphasis on a priority concern will have a consequential effect on other areas that must be addressed to see the project through. This effect is in the form of a constraint. The priority-constraint balance 'moves' around during design development until it finally settles, at which point compromises are accepted for the sake of completing the project and finalising the product design for commercialisation (Figure 2).

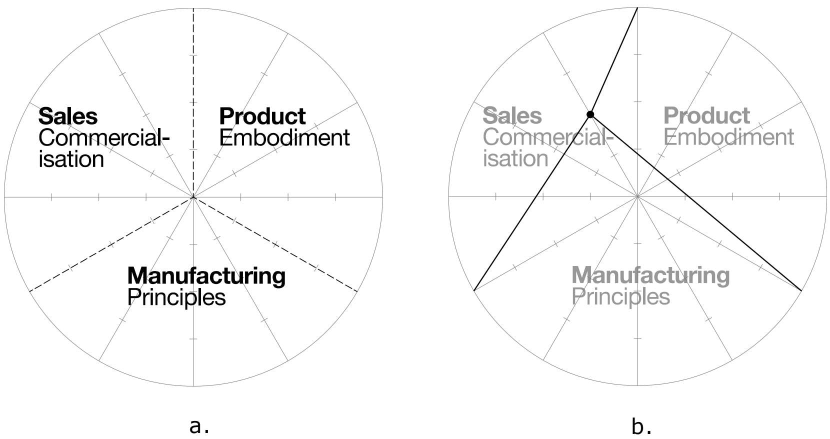

Figure 2: The design parameters and the inter-relationship between them. Figure 2a. shows the priorities balanced, however, data indicates that during innovation projects designers prioritise certain parameter fields. Figure 2b. shows that when there is a priority increase in one parameter field there is a consequential constraint applied to an associated parameter.

The interview data indicates that three core factors govern or at least direct the shaping of the innovation from it's conceptual state to a physical embodiment developed for production and commercialisation. These are consistent in all interviews. They are 1) Sales and Commercialisation, 2) Product Embodiment and 3) Manufacturing Principles. They are also consistent with the competing constraints model by Tim Brown (2009) that describes desirability, viability and feasibility. In the case of products the criteria's for success that

Brown uses in his model - desirability, viability and feasibility correspond to product embodiment, sales and commercialisation and manufacturing principles of the integrated parameter model. Where Brown advocates an achievable balance (in his Nintendo Wii) example, I argue that the innovation of that design is a result of prioritising product embodiment forcing a constraint on manufacturing and commercialisation that was dealt with in an equally innovative way by rationalising the processing capabilities of the unit. Compared to their competitors at the time the Wii was a lot cheaper, the graphics resolution was significantly lower and they developed in-house software to support the new control interface. Verganti (2009) refers to this case as well, noting that at the core of the (Wii) product concept is the physical experience noting this as a meaning change and the focus of their innovation strategy. Consequently, the Wii did not spend time and resources substituting old technology. Nintendo invested in three-dimensional accelerometers and creating a new experience. In order to make that work, the Wii has less powerful graphics capability and therefore costs less than their competitors. A trade-off was made. In both Brown's and Verganti's research, there is a clear link between issues of embodiment, manufacturing and commercialisation. This paper seeks to explore the notion of a dynamic interrelationship between these factors - not to highlight where compromises must be made, but more accurately, to make explicit where the priorities for the development of the innovation are positioned and to make aware that as a result there will be a consequential constraint. Dealing with the constraint need not mean wholesale compromise or a 'loss'. It simply means that the constraint must be managed.

4.1 THE PRIORITY FIELDS

There are three priority fields identified in the research data. These have been determined based on a thematic analysis of interview data. They are:

1. Sales and commercialisation
2. Product embodiment
3. Manufacturing principles

Sales and commercialisation factors include methods of selling the product, licensing intellectual property, business contracts, business strategy, modeling and forecasting along with any actions that are associated with the process of getting the product to market and commercialisation planning. This field is most compatible with issues of viability (Brown 2009) concerning the establishment of the best business strategy for market success. Product embodiment factors include concerns regarding the form, structure, aesthetics, materiality, mechanics, interface, ergonomics, etc. of the product design. This field is most compatible with Browns description of desirability in the establishment of product features and appearance. Manufacturing principles refers to aspects of production assembly (including component / software selection), materiality as a consequence of manufacturing limitations, etc. The field of manufacturing principles is most compatible with Browns description of feasibility, in that for product design the concerns of working with an appropriate means of production are geared toward ensuring the concept can be manufactured.

5. THE INTEGRATED PARAMETER MODEL

The following examples are taken from research on self-initiated design projects that have successfully incorporated innovative design ideas. In order to maintain confidentiality we have omitted the designers names, the names of the products and disguised some of the details of the product designs.

5.1 DESIGN 1 : PORTABLE PHOTO-STUDIO

The product is an innovative portable photography studio approximately the size of a laptop computer in its folded form. The designer presented this design as a self-initiated design project developed to help him in his own work. He uses the portable studio to take photographs of small products and components when visiting clients. A key feature of the design is that it is constructed from light gauge metal sheet and contains CNC machined metal components for an attached and configurable arm where the user can place their camera. In the designers description of the development of the project the reasons for the decision to construct the product in metal are explained and the consequences of this decision become evident when considering the limited commercial potential of the product in its current (sheet metal) form. During the interview the designer states;

> "It's a sheet metal enclosure, I've been doing a lot of work with sheet metal, so I've tried to innovate with the sheet metal and utilize it's properties - structure and magnetism."

and continues, regarding the machined parts;

> "I don't machine those, I outsource those. I've got a colleague who I've used for three or four years now, who works on the foam models that I do."

These remarks demonstrate that the designer has prioritised the use of sheet metal fabrication in developing the concept from idea to physical product. The reasons for doing so are based on having knowledge and experience in working extensively with sheet metal. In the interview, he does not refer to the design of the enclosure in terms of its functional or aesthetic performance in the first place - his priority is to exploit (Martin, 2009) existing knowledge to innovate in a particular material (thereby working within a set of manufacturing principles). In a separate statement the designer reinforces this aspiration for self-initiated design;

> "So sometimes you want to step back from it and say, 'well, a bit of me time'. I'd like to – you know, with all the knowledge that I have and the skills that I have gathered and the information that I've collected – I'd like to now exercise something that would make my life easier or would make my life more enjoyable .... and if it makes my life more enjoyable, I'm sure it would impact on other people as well."

This comment is certainly at odds with a priority on issues of sales and commercialisation, where the focus would be on the consumer and the market possibility. The designer is motivated by expressing an idea and 'exercising' existing knowledge as a key to innovation. It should be noted that there are functional (product embodiment) advantages that come by setting the priority on sheet metal production. He states,

> "You can actually use magnets on the surface and what happens is the tray folds out and lifts up and you use magnets to hold the backdrop."

So the priority is split in this case. The primary priority is on manufacturing principles and the secondary one is on product embodiment. This is represented in Figure 3. The priority field is larger and consequently positions the constraint in the sales and commercialisation field. The diagram represents the dynamic inter-relationship between these three factors, evident in the interview data.

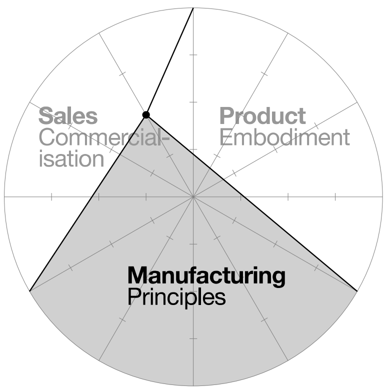

Figure 3: Designer 1 - Portable Photo Studio

The consequence of embodying the design in this way has a serious impact on its sales and commercialisation opportunity. Cost of production was high so the units were expensive and could only be produced in very small quantity.

> "The suppliers I used were all the people that I currently use but they're very expensive...At the moment I went for a short run of five and sold three of them. I took the other two myself."

5.2 DESIGN 2 : PLASTIC WALLET

The plastic wallet uses a thermoplastic elastomer as the base material and is conceived as an innovation not only in its departure from leather but in its construction. The designer runs a long established Sydney based design consultancy and has had a number of experiences in attempting to license intellectual property with limited success. The designer's experience with the complications of the licensing model, motivates a business prioritisation in the development of self-initiated designs as shown in Figure 4.

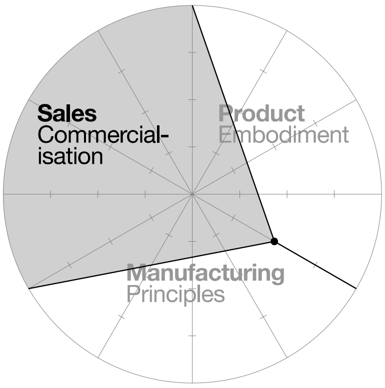

Figure 4: Designer 2 - Plastic Wallet

The designer is determined to format the product for a model of commercialisation that maximises its ability to be sold effectively over the internet and delivered to the consumer quickly and reliably. Tied to this as well - a product that would "sell on its own", without the need of impacting negatively on his primary business, which is consultancy services.

> "We've got two strategies the first thing is: with self-initiated work we started another company called .... So we want to separate the two. Have one that was a consulting based company that works for fees and another one that works for alternate revenue streams."

When asked about the connection between the completion point for the design project and the formation of the company for self-initiated designs, he responds;

> "Oh, the company came first. Before there was a product, because the strategy was there to firstly, do self-initiated projects."

Regarding the wallet design;

> "So, why a wallet is easy (is) because firstly it meets the criteria set. Firstly, everybody has one. It can be sold over the internet day and night. It's not regional, they can sell in Portugal, Paris or Maroubra. It doesn’t require service departments."

The above statement echo's a trend in micro-branding (Ball & Overhill, 2012) self-initiated design that sets the focus on strategy. The consequence was that the product innovation of a 'plastic wallet' was somewhat constrained in terms of manufacture and product embodiment. Some functional challenges needed to be overcome in dealing with those constraints and to hold true to the viability of the business model deemed so important. The designer comments on the use of material and manufacturing;

> "We went to Bayer, material science (for a client project). They said you can sonic weld this (the TPE material), you can mould form it, you can do this or that, okay - we have Bayer material science. So you put this together with nothing happening in wallets, it meets our manufacturing criteria. We can outsource the whole manufacturing somewhere, we don't need to buy a plant."

This statement indicates that the manufacturing criteria sits under a broader business strategy to outsource production, meaning that the manufacturing principles and, consequently, product embodiment are constrained by a sales and commercialisation priority.

5.3 DESIGN 3 : SWIM GOGGLES

The goggles were designed with ergonomics in mind as a priority. The innovation is that they position the highest pressure on the face on the bone structure not the delicate soft areas around the eye's - making them more comfortable. To hold true to this the designer needed to find a compatible manufacturing company with the knowledge, reputation and capability to produce the product.

> "Conventional goggles were designed for relatively short pool swims. They failed to account for the structure of the face, making them uncomfortable and leak-prone. (With our design) the pressure from the lens is applied to the bone structure of the face."

Upon finding this manufacturer he was required to "make compromises" when he entered into a production licensing agreement with the company. This however, meant that the design could be commercialised successfully. The results of the prioritisation and constraints are shown in Figure 5.

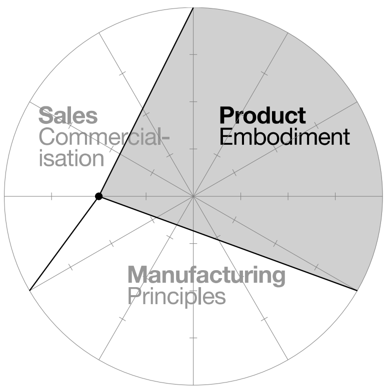

Figure 5: Design 3 - Swim Goggles

The product is first conceived based on experiential knowledge.

> "[N]early everyone in the team is active and involved in water sports, et cetera. That specific activity would be mine but it was familiar enough to the guys, so everyone's been in the water and everyone's done surfing, et cetera."

Regarding the commercial pathway;

> "We conceived of the thing, talked to people, found a company in the US that were interested in it, developed it further in partnership with that company and then tooled up and the product is in production and won an Australian Design Award ... We found that...from design to production there were a number of compromises made which seemed to be a bit of a grey area in the licensing type structure."

These comments indicate that there is a determination to hold true to the product embodiment as it represents the intellectual property (ergonomics innovation) and key bargaining tool for the designer in negotiating a licensing agreement with the US Manufacturer. The designer must therefore accept and work within the constraints imposed by the sales and commercialisation procedures of that particular manufacturing firm.

6. CONCLUSION

The research indicates that designers prioritise aspects of design concern and that consequently constraints are applied to associated fields of activity equally necessary in taking a concept from idea to marketable product. The nature of this finding is represented in the integrated parameter model. The model dynamically-interrelates three parameter fields of design activity that must be engaged to take a design from concept to physical product. Research into self-initiated product design (open-ended and non-prescriptive projects) confirms that a non-linear, purpose built design process applies in achieving innovation that can be commercialised. A relationship between research into self-initiated product design and applications for secondary and tertiary design major projects has been established (Walden & Kokotovich, 2012) where the major projects are self-initiated by the student. This research extends upon that model by providing a way for professional and student designers to identify the prioritisation and constraints to be managed in establishment of linking aspects of novelty (innovation), the support network (external advice) and aspects of project control (the strategic management of design tasks) together. Following research into design education that finds that open-ended design challenges require supporting students through a flexible design process (Goldschmidt and Rogers, 2013); new tools must be provided. It is considered that the integrated parameter model presented in this paper offers a potential guide for students and mentors to refer to in establishing a focus, discussing changes in emphasis; and monitoring feedback loops in design decision making, without prescribing strict methods or procedures that may limit innovation or encourage fixation.

REFERENCES:

Ball, R. & Overhill, H., 2012, *Design Direct: How to start your own micro brand*, PTeC Publishers, Hong Kong

Brown, T., *Change by design: How design thinking transforms organisations and inspires innovation*, HarperCollins Publishers, NY

Cross, N., 2007, *Designerly ways of knowing*, Birkhäuser, London

Dorst, K., 2011, 'The core of 'design thinking' and its application', *Design Studies*, Vol. 32, No. 6, pp.521-532

Dorst, K., 2003, *Understanding design: 150 Reflections on being a designer*, BIS Publishers, Amsterdam

Fricke, G. 1996, 'Successful individual approaches in engineering design', *Research in Engineering Design*, Vol. 8, pp. 151-165.

Goldschmidt, G. & Rogers, P., 2013, 'The design thinking approaches of three different groups of designers based on self-reports', *Design Studies*, Vol. 34, No. 4, pp. 454-471.

Lawson, B. & Dorst, K., 2009, *Design expertise*, Architectural Press, Oxford

Lawson, B., Bassanino, M., et al. 2003, 'Intentions, practices and aspirations: Understanding learning in design.' *Design Studies*, Vol. 24, No. 4, pp.327-339.

Leitner, M., Innelle, G., Yauner, F., 2013, 'Different perceptions of the design process in the context of DesignArt', *Design Studies*, Vol. 34, No. 4, pp.494-513.

Liu, Z. 2011, 'A research on an integrated innovation pattern between manufacturing and service industry in China', *Product Innovation Management (ICPIM), 2011 6th International Conference*, 16-17 July 2011, pp. 198-202.

Martin, R., 2009, *The design of business: Why design thinking is the next competitive advantage*, Harvard Business Press, Boston, Mass.

Popovic, V., 2004, 'Expertise development in product design - strategic and domain-specific knowledge connections', *Design Studies*, Vol. 25, No. 5, pp.527-545.

Smulders, F. E. & Bakker, H. J., 2012, 'Modelling the inter-subjective level of innovation', *International Journal of Technology Management*, Vol. 60(3/4), pp. 221-241.

Verganti, R., 2009, *Design-driven innovation: Changing the rules of competition by radically innovating what things mean*, Harvard Business Press, Boston, Mass.

Walden, R.J. & Kokotovich, V. 2012, 'Supporting Student Learning in Relation to Entrepreneurial Innovation in Self-initiated Industrial Design Major Projects', (Ed.) Middleton, H., *7th Biennial International Conference on Technology Education Research 2012*, pp.155-164.