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Decision Making in Product Design: Bridging the gap between inception and reality

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Abstract

Product Design in the modern world is a complex multifaceted discipline comprising of many skills and applications. It also operates in broader cross-disciplinary contexts within direct teams, while also contributing to the strategic business processes of commercial enterprises, government/councils and not for profit organizations. It is no longer a purely creative problem solving activity where a good idea or innovation is enough to push forward a new product. For the majority of the design profession the days of design on the back of an envelope are gone. Today design is a structured activity with recognizable and repeatable methodologies and processes. Within this the profession is acknowledging and aligning with the principles of business management. A consequence of this is that designers are being asked to undertake increasingly complex challenges where the consequences of making good or bad decisions have far reaching implications for the future of an organization. Education needs to train designers to recognize and operate in these complex situations. As a response Universities now include project or design management within curriculum.

'The new program should equip the students with not only the ability to design, manufacture and test design solutions; but also with a firm knowledge of business strategy' (Guo, 2015)

However the authors have recognized a gap within the profession and education for a more structured and validated approach to decision making within the design process (Norman, 2010). This paper outlines a pilot study within a student project whereby professional decision making tools are introduced to final year students and used to validate selection of appropriate designs from initial feasibility concepts against a hierarchy of criteria. Would designers see the value or would they perceive it as an intrusive addition to what they believe should be an intuitive process?

Key words

project management, decision making, selection tools.

1 Introduction

Product Design has grown rapidly in the last few years from a creative response, solving problems in imaginative ways, to a more complex professional activity. With the former, product designers justified their work through presenting ideas as images and models, the value of which being defined by how "wow'd" the client was at the presentation. Although this is a simplistic view it reflects the starting point of the profession which is gradually becoming more sophisticated in how ideas need to be justified against contexts, and validated using repeatable design processes and methodology. Two key pieces of work are the book Design Management by Kathryn Best (2006), which crystallized our understanding of the value of design to industry and the UK's Design Council Double Diamond description of the Design Process (Design Council, 2015). The Double Diamond is a way of visualizing the design process as four discrete stages Discover-Define-Develop-Deliver. The latter two stages develop and deliver are well understood, where a designer's creative response to a given product specification, or narrow brief supplied by another is made real through concept generation, review, refinement and prototyping, combined with an understanding of production processes. This Develop and Deliver window from brief to product reality is the bedrock of what is taught in universities and colleges. It forms the essential proving ground for building skills and creative sensibilities. With the increasing acceptance of the idea that Design Thinking is a legitimate business tool (Rauth, Carlgren & Elmquist, 2014) to drive innovation designers have developed beyond this reactive role to working at the very inception point of product creation, to identifying what could be, as much as how to make it a reality. There are now numerous tools and methods (Kumar, 2012) available to the designer to formalize research into new possibilities driven from the perspective of the end user. These can range anywhere from ethnographic observation techniques to direct immersion of the designer in the user environment. The Discover phase of the Double Diamond process is specifically aimed at focusing designers on conducting this first hand research to quiz needs prior to formulating Design Specifications. This is a key step change in that it allows designers to interrogate real rather than perceived needs, ensuring that they are answering the correct question in the brief. Much work has been done in this area, indeed Design Research is now a professional discipline in its own capacity (Milton & Rodgers, 2013; Laurel, 2003; Muratovski, 2016). However, the define phase is still a grey area. That is, how do we move from a new level of user needs understanding, including design propositions, within the Discover phase to a Product Specification and viable business proposition? What criteria do we use to make choices? This is a poignant question within the Develop and Deliver phases as well, how exactly do we make decisions? We may be answering the right questions but with the wrong answers, or we may be providing great answers, but to questions that don't need asking.

This paper is the start of a collaborative research project between Industry and Academia investigating current understanding of the above issues and tentative field-work with a student project to identify criteria, and the priority that should be placed on those criteria, by which choices can be made using a tool created with the industrial partner (HCL Technologies Ltd).

2 the design process

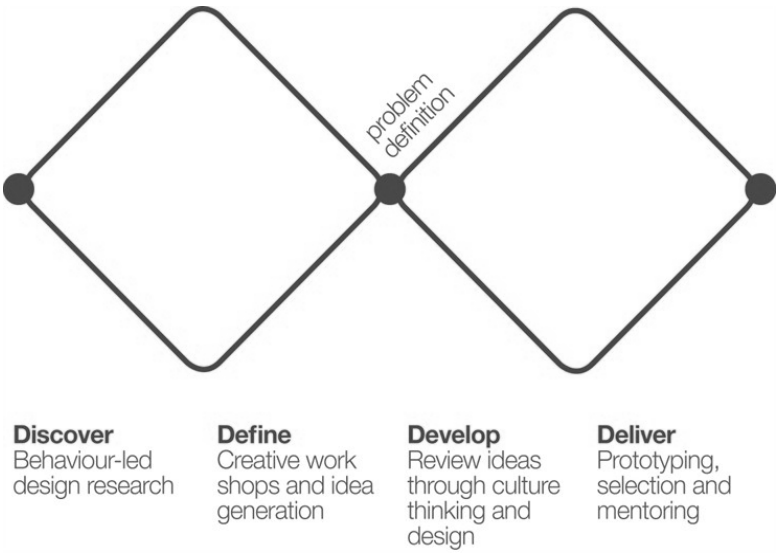


Figure 1. The Design Council Double Diamond Design Process (Design Council, 2015)

The articulation of what constitutes a Design Process is not new (Jones, 1992; Lawson, 1995; Guo, 2015), and has evolved into a sophisticated process both in terms of a channel for creativity and a commercial construct. However there is still a tendency to regard design as an unpredictable creative process which generates invention, right brain or outside the box thinking, misunderstood in the external world. Whereas creativity, identifying new needs and responding with possibilities is indeed part of design there is a difference between Invention, Innovation and Design (Best, 2006; Lawson, 1995). Although none of these are the exclusive domain of product designers a professional designer does understand and follow processes to get from invention (or other starting point) to realization. The latter two, innovation and design, are a disciplined process by which products (products, rather than service or system, used as an example in the context of this paper) are realized in response to needs or requirements. Product or Industrial Design as taught in a modern University is a complex vehicle which both reflects commercial practice and challenges existing paradigms. An integral part of this is the teaching of design process or method. At the University of Hertfordshire after a broad discussion on the processes available the students follow the Design Councils Double Diamond Process (DDP), see Figure 1, as it is both visual and clearly articulated. It is also important as it links the traditional commercial understanding or utilization of design as a development and delivery process with the need to discover or research user needs. This is crucial to good design as design research is where real needs or possibilities are both uncovered and understood. As Sir Ken Robinson expressed it:

"You cannot solve a wrong problem" (Robinson, 2013)

Tools used in the Discover phase and idea generation aspects of the define phase have been adopted by design professionals to help articulate the benefits of Design Thinking and creative approaches, and much work has been done here, indeed Design Research is a profession in its own right. This plays strongly into the ability of designers to expand possibilities and identify a plethora of opportunities. What is less understood is how students and designers navigate from the many opportunities identified in the early phases to a validated development pathway. What is the decision making process? Is it arbitrary or does it follow a clear set of value judgments? This conundrum is echoed on the critical decision pathway from the define phase to the develop phase. The authors believe that there is a need for more user focused and design led processes to fill the design decision gap, see Figure 2, between Define and Develop phases. There is a need to provide designers with tools (Diels & Ghassan, 2015) that give them confidence to become a crucial part of the decision team, and be less inclined to abdicate decision making to financial, marketing and engineering gate keepers.

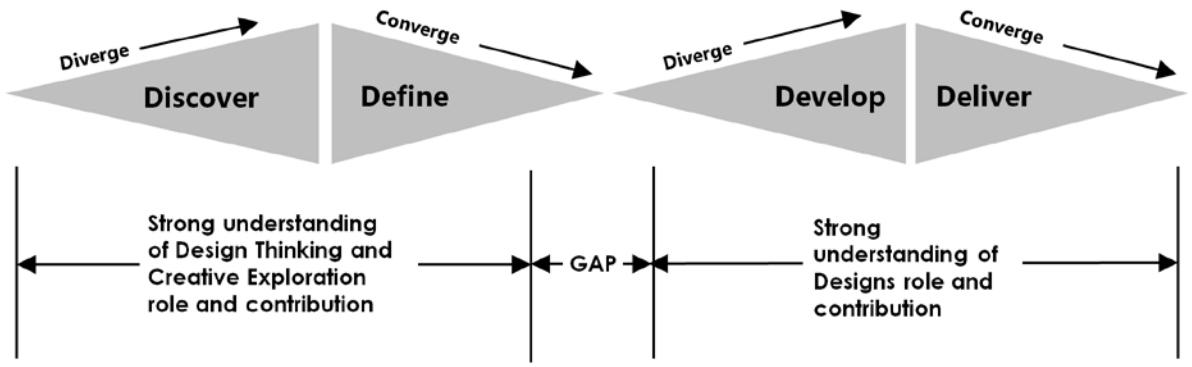


Figure 2. Design Decision Gap in the DDP

If some of the commonly used tools and techniques are mapped against the DDP, see Figure 3, it can be seen that the closer to a critical decision point in a project the more quantitative tools and techniques come to the fore. Designers by their very nature tend towards the more qualitative tools and techniques, which often results in their voice not being heard at the crucial decision points in the product creation process. While there is undoubtedly a shift to acceptance of the value of the qualitative input at a theoretical and ideological level the decision makers in organizations still tend to be from a more commercial focused background and are under relentless pressure to deliver results at minimal risk. They desire an algorithmic approach to innovation where a specific input to the process repeatedly guarantees a successful outcome. Basing decisions on metrics, even if those metrics are disconnected from the reality of user needs and customer desires, provides the illusion of certainty and something to blame if things go wrong. The need for

organizations to break out of this approach is crucial if they want to take advantage of Design Thinking. As Roger Martin states:

"Knowledge Management systems will organize all the knowledge in a corporation, but they cannot produce imaginative breakthroughs. Advances in knowledge emerge from the pursuit of valid results. That pursuit calls for a different set of tools and processes…" (Martin, 2009)

The use of analytical tools that quantify subjective input may provide an opportunity for designers to engage with the decision process more fully. If designers cannot articulate, validate and present reasons for their recommendations it is likely to remain the case that designers will continue to be in the position of creator-artisan looking to the judgement and approval of patrons in the form of clients or senior management decision makers. It is rare for a designer to present one idea to a patron accompanied by a well thought out validation and rationale; rather, it is more likely that the designer will present three or four ideas for the patron to pass judgment upon. In this way the responsibility for outcomes passes to the patron. As designers engage earlier in the new product development process, with much of their work being in the pre-definition phase, they will need to take responsibility for the increased impact their input has on success or failure. They need to be judge as well as creator.

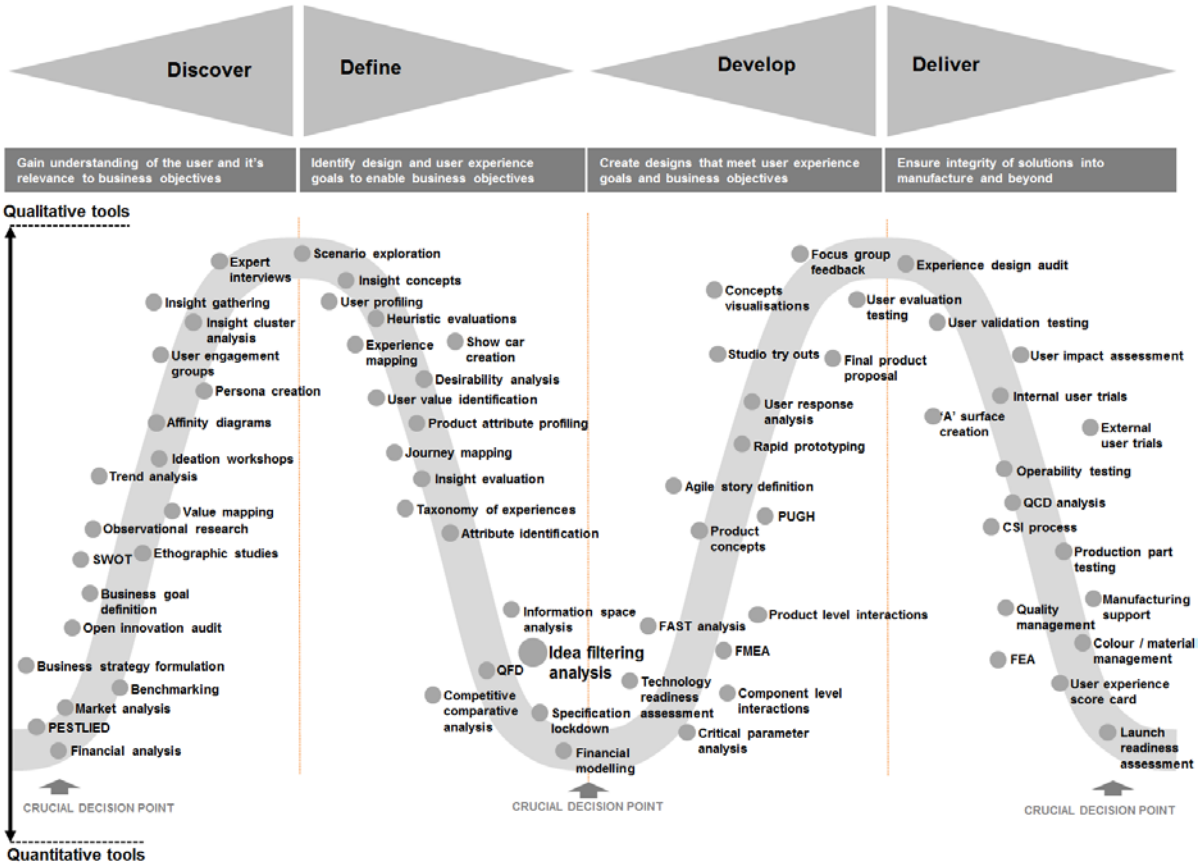


Figure 3. HCL Ltd. Tools and Techniques mapping.

For designers to take on this role the design education system will need to provide an analytical framework for design students to build upon, while continuing to provide the opportunity for the development of skills and creative flair. The aim being to provide students with the tools and techniques that will allow them to have confidence in their decision making and instill in them an understanding of the importance of robust design research in gathering valid data Within the project outlined below students were introduced to some of the tools currently available to aid decision making.

3 The student project

To explore with students the available tools to validate decision making in design a reflective task was incorporated into a design project. This 'new to students' aspect of design involved a realization of the complexity of the process as well as creativity within design. In collaboration with HCL Technologies Ltd (HCL) a challenge was set to final year Industrial and Product Design students to individually:

'Design and test a product to help the disadvantaged utilizing the technology of 3D printing'

The project was structured around the DDP. The first phase was to identify needs through research and present these 'design insights' (Taura & Nagai, 2008), back to the company, considered as the Discover Phase. Through further observation and refinement students then responded creatively generating design possibilities, in response to identified needs, as sketch sheets. This in effect reflected the first aspect of the define stage. Another session took place with students presenting these concepts. This was followed by a seminar facilitated by HCL and University of Hertfordshire, on how to make appropriate selection from the generated possibilities. In this session a selected number of assessment tools and matrices were introduced to the students. These included QFD (Quality Function Deployment), Pugh Analysis (Pugh, 1990) and Desirability Competitive Positioning Model (Wynn, 2014). It was hoped that by giving the students a clear understanding of the importance of decision criteria early on that it would give them an insight into how professions outside design use models for decision making.

The aim was to expose the students to rigorous selection tools and processes that would help them dispassionately assess and define what design directions should progress to development. The outcome of the exercise was to gain an understanding as to whether having a defined process for concept assessment would impart more confidence in the students to defending their decision rationale. Of the tools introduced to the students the tool chosen for the exercise was one created within HCL called the Idea Filtering Analysis model. It was chosen due to its position in the development process, see figure 3, and its combining of an analytical approach with subjective input. The model uses criteria as identified during the Discover phase (step 1), and through a combination of heuristic evaluation and user engagement stack ranks them in order of relevance to user needs (step 2). Each criteria is then given a minimum pass mark (step 3), i.e. the minimum level that users would deem the criteria met sufficiently to avoid a given idea or concept being

rejected by the user. This is the level that meets user expectations, exceeding this does not gain anything over the competition unless it is as a tie breaker when only two contenders remain. Each idea generated during the early define phase (step 4) is then scored against the criteria (Step 5). In this way the ideas pass through a series of criteria filters that identifies the idea that is likely to provide the best chance of meeting the user needs. The outcome is displayed as a visual chart where the idea that gets closest to the center is the winner. While numeric outcomes are sufficient to identify the winner, visualizing the results was considered important to allow designers to relate to the outcome. Figure 4 shows example data displayed in the Idea Filtering Analysis model, and illustrates how ideas can be exceptional against many of the criteria, exceeding user expectations, yet fail if the crucial early criteria filters are not passed. Idea 9 can be seen to be out performing idea 8 in all areas except the crucial highest priority criteria (criteria D). Meaning an otherwise very strong idea such as idea 9 fails and a better focused idea such as idea 8 succeeds.

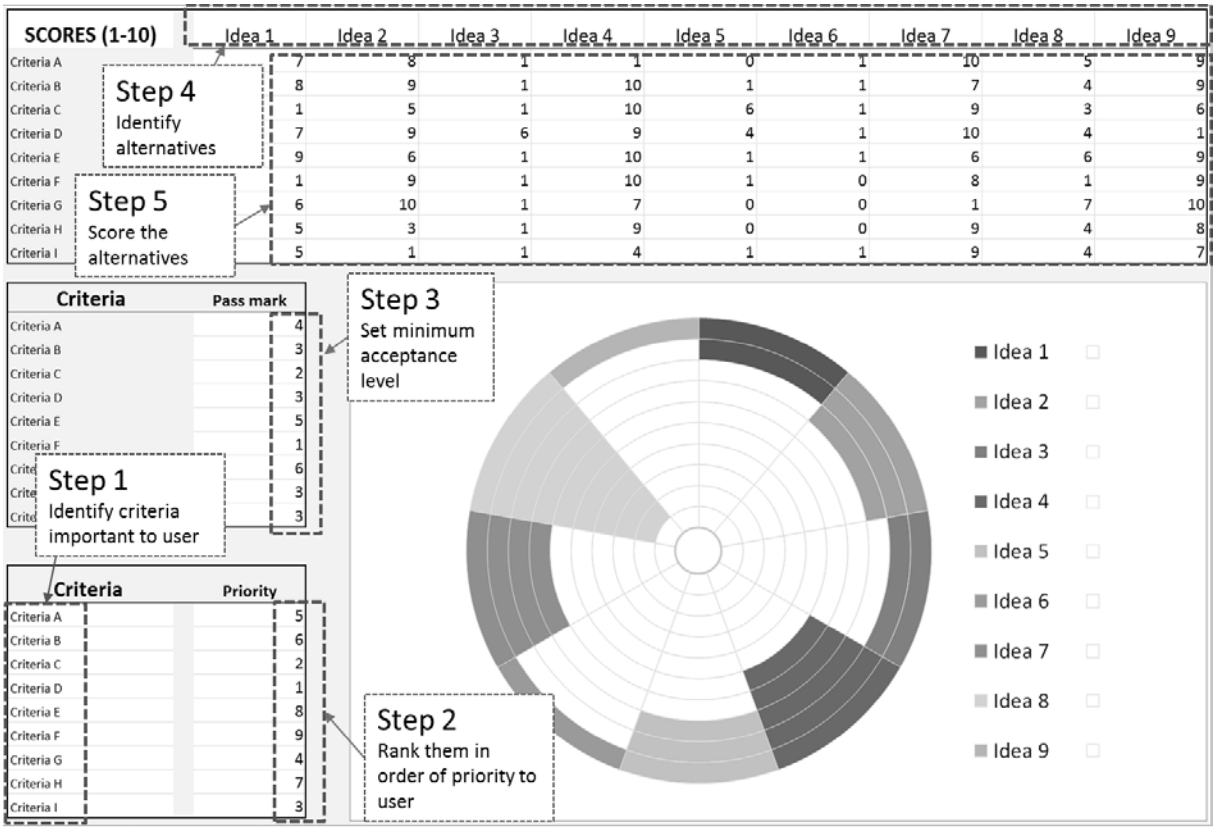
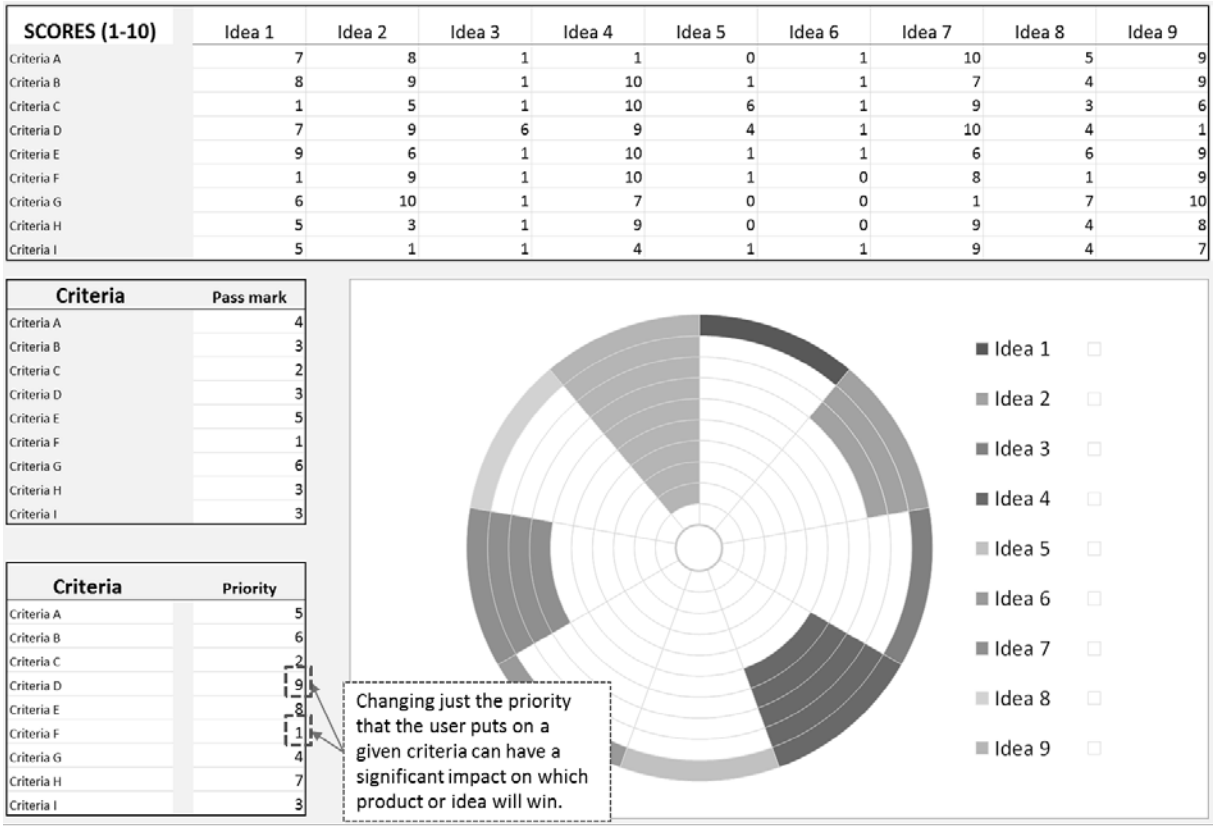


Figure 4 Idea Filtering Analysis.

Figure 5 shows the significant impact that changing the priority of criteria D can have and illustrates the complex and delicate interrelationship between criteria, user priorities and to what level does an idea address those criteria. The change in priority of criteria D means that idea 9 is able to take advantage of its strength in addressing other criteria to win out over weaker ideas. This tool allowed the students to run alternative interpretations of data and provided a real example to the

students of how lack of understanding of the user in minor ways can have a disproportionate impact on success. In demonstrating this sensitivity it was hoped that the students would also see the importance of good quality design research that provides data they can critically evaluate and have confidence in utilizing within a design process.



SCORES (1-10)	Idea 1	Idea 2	Idea 3	Idea 4	Idea 5	Idea 6	Idea 7	Idea 8	Idea 9
Criteria A	7	8	1	1	0	1	10	5	9
Criteria B	8	9	1	10	1	1	7	4	9
Criteria C	1	5	1	10	6	1	9	3	6
Criteria D	7	9	6	9	4	1	10	4	1
Criteria E	9	6	1	10	1	1	6	6	9
Criteria F	1	9	1	10	1	0	8	1	9
Criteria G	6	10	1	7	0	0	1	7	10
Criteria H	5	3	1	9	0	0	9	4	8
Criteria I	5	1	1	4	1	1	9	4	7

Criteria	Pass mark
Criteria A	4
Criteria B	3
Criteria C	2
Criteria D	3
Criteria E	5
Criteria F	1
Criteria G	6
Criteria H	3
Criteria I	3

Criteria	Priority
Criteria A	5
Criteria B	6
Criteria C	2
Criteria D	9
Criteria E	8
Criteria F	1
Criteria G	4
Criteria H	7
Criteria I	3

Figure 5 Idea Filtering Analysis – impact of minor change in priorities.

The students were required to present the outcomes of their idea filtering analysis to a surrogate client, represented by a business manager from HCL, as a set of recommendations in the form of product attributes aligned to the prioritized criteria. The emphasis was on requiring the students to make decisions rather than the more traditional format of the designer presenting work and the client choosing a development direction. Having used the tool to support their recommendations the students were asked to provide feedback on whether they found it useful in articulating their rationale and decision as to which of their concept ideas deserved to progress to development.

The continuation of the project allowed students to refine concepts into practical design proposals, within the manufacturing limitations and possibilities of 3D Printing. This was in line with the develop phase of the DDP. Students were charged with continuing to use the tool/matrices in their decision making pathway as ongoing validation of their design selection. At the next formal meeting final proposals in the form of 2D Presentation were presented along with the completed

tools/matrices. Did they feel more confident in making and defending their decisions by having formalized analysis tools?

4 Student feedback

The project was undertaken by 12 students. At the end of the project each student was given a short questionnaire (9 responses). The authors accept that due to the low number of participants the results are indicative rather than conclusive. However the following observations from the students are invaluable for the construction or refinement of assessment tools within an educational context. The questionnaire included the following questions:

- *Did you find the Tools useful?*

60% stated that they did not find the tools useful. However when analyzing comments made to other questions (see below) this is in part an indication of not wanting to externalize decision making and a preference to do what the student wanted rather than deliver against criteria.

- *Did you develop the Design Concept indicated as the best aggregate score on the Pugh Diagram?*

60% of the students responded yes which appears to be in conflict with the answer to the question above. Of those who answered no, comments such as *"I trusted my instinct"* and *"I developed the one I wanted anyway"* were given. This indicates a lack of engagement with the complex business world in which design operates. That is although the tools may not be the full answer professional designers do need to respond to external demands and criteria rather than just do what they want. It is also important to frame decision making in a business facing language.

- *Did you find the tools useful in thinking about the criteria for the design even if you did not adhere to the findings?*

This is probably the most insightful feedback. That is although there are issues with engagement with current tools they did expand the understanding of process and decision making. Two key comments were *"Yes new perspective but ignored the ratings"* and *"more insightful than useful"*

- *List three good things about the tools.*

Although there was mixed opinions about the value of the tools (answers to questions above) there was a general feeling that they could assist in making rational choices, particularly when there are multiple design options or opportunities and that they "*allow designers to justify their decisions*"

- *List three areas in which the tools could be improved.*

Interestingly only 40% of students answered this question. However, those who did felt the diagrams could be simpler both in the application of data and visually.

5 Further research and development

This is early stage research mapping out a territory for investigation. Building upon existing frameworks and protocols (Best, 2006; British Standards Institution, 2008), the value of the preliminary project can be summed up in the following points:

- To understand the modern design profession design students should contextualise their creativity and skills against robust methodologies and practices.
- Decision making, milestones and a critical pathway are crucial to successful projects.
- Tools and Matrices are valuable aids to both decision making and communicating these to external associates (clients).
- Evaluation tools are relevant at different points on the critical pathway within a design process, and these tools need to be explored further.
- There is some resistance to analytical approaches from designers themselves and ways need to be found to communicate the value to these approaches in a way that is not seen as intruding on the creative and intuitive strengths of designers.

There are numerous tools that can be used to compile and analyze subjective data and present this data in a way that can be interpreted by non-designers, however, until designers themselves see the value that these tools can provide there is likely to be resistance to their adoption.

One key observation by both HCL and University of Hertfordshire staff was that selection tools such as the ones outlined in this paper cannot be introduced to students without prior work on the professional processes involved within the business of the Creative Industries. That is, the value of selection tools is greatest when design decisions are externalized against commercial criteria rather than internalized with the designer, or in the instance, the student making all the decisions against their own preferences. This is also a key differential between the professional product designer and the designer maker or artisan designer who is controlling the whole of the design process from conception to manufacture. The selection tools bring a business context and language to the design process that can help designers validate and rationalize their thoughts in a way that is understood by other participants in the decision process. However, the authors believe that if selection tools of the type explored during the student project are to be taught effectively they need to be introduced to students only after an understanding of the broader business processes of design are gained. Within the three year Product & Industrial Design curriculum at the University of Hertfordshire the creative and business processes are taught as follows; the creative process is taught in the first year while business aspects are introduced in the second year (simplified outline). Thus selection tools, taught in the final year, are building on this learning curve only when the students have a mature understanding of Product Design and are generating personal portfolios demonstrating their capacity to enter and practice within the professional discipline.

Building on these early observations more structured research is needed to explore the utilization of tools within a broader range of design processes. Even within the DDP tools can be used at the end of the define stage and also the development stage, will they be the same tools? This needs

further investigation. Student projects will be used to explore development of tools appropriate to design strategies. In the project described above professional tools were introduced to the students. On a positive note this also made students aware of the complex nature of decision making in a business context. Commercial decisions normally have inputs from a range of disciplines covering all affected parties such as finance, marketing and production as well as user/customer concerns. However some students struggled with the complexity of professional criteria and there is the potential for the development of entry level tools which match the students understanding of commercial design in a similar way to understanding manufacturing processes. That is a professional designer through experience has a better grasp of rationalizing production processes than students who have limited experience in these technologies. One aspect of this is the visual nature (info graphics) of the tools and grids and there is an opportunity to simplify the presentation here. Whereas they should be robust and validated they also need to be accessible so that information can be understood by a range of professionals beyond design. Our aim is:

Creation of a broader balanced scorecard approach and guidelines that ensures the more qualitative aspects of project appraisal is given an equal weighting with the more conventional quantitative approaches, and seeks to identify opportunities for successful innovation that would otherwise have been overlooked. In particular to provide an approach that is tailored for use by designers and is perceived by them as a real value in building credibility and helping them articulate real value.

While introducing the concepts to students is considered particularly useful there is also a potential gap within the practicing design profession with regard to becoming more prominent in decision making and it is believed that by building student confidence by providing them with the right tools they will be better prepared when entering the profession.

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