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 cross-disciplinary contexts both in direct teams but also contributing to strategic business of manufacturers, government/councils and not for profit organisations. 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 is that designers are capable of undertaking ever increasingly complex challenges. Education needs to train designers to recognise and operate in these complex situations. As a response Universities now include project or design management within curriculum.
'The new programme 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' [1]
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. 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 concepts against a hierarchy of criteria.

Keywords: 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 [2] which crystallised our understanding of the value of design to industry and the UK's Design Council Double Diamond description of the Design Process [3]. The Double Diamond is a way of visualising 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 is made real through an understanding of production processes. The Discover phase allows designers to conduct first hand research to quiz needs prior to formulating Design Specification. 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 [4], [5], [6]. However, the Define phase is still a grey area. That is, how do we move from a new level of 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 by which choices can be made using a tool created with the industrial partner (HCL Technologies Ltd).
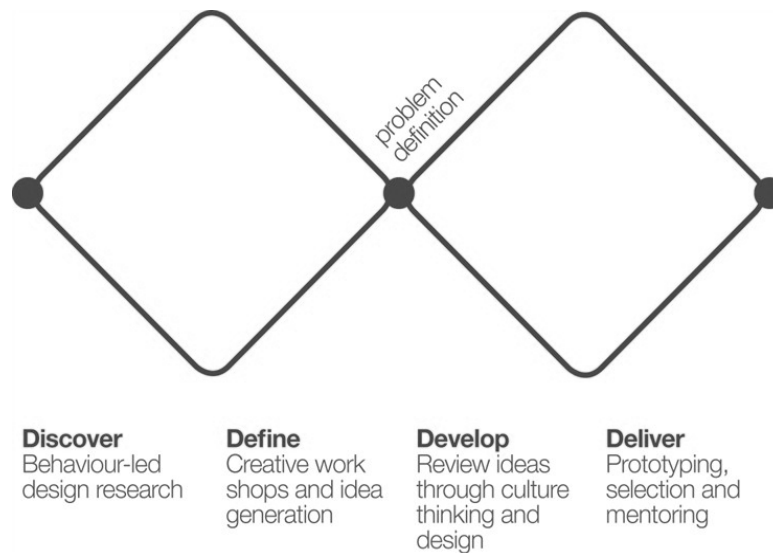
2   THE DESIGN PROCESS

Figure 1. The Design Council Double Diamond Design Process [2]

The articulation of what constitutes a Design Process is not new [7], [8], [1], 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 (expand and reference). The latter two are a disciplined process by which products (products used as an example in the context of this paper) are realised 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 utilisation of design as a development and delivery process with the need to discover or research user needs. This is key 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" [9].

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. 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 valued judgements? 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 decision gap, see Figure 2, between Define and Develop phases. There is a need to provide designers with tools [10], that give them confidence to

become a crucial part of the decision team, and be less inclined to abdicate decision making to financial and marketing gate keepers.
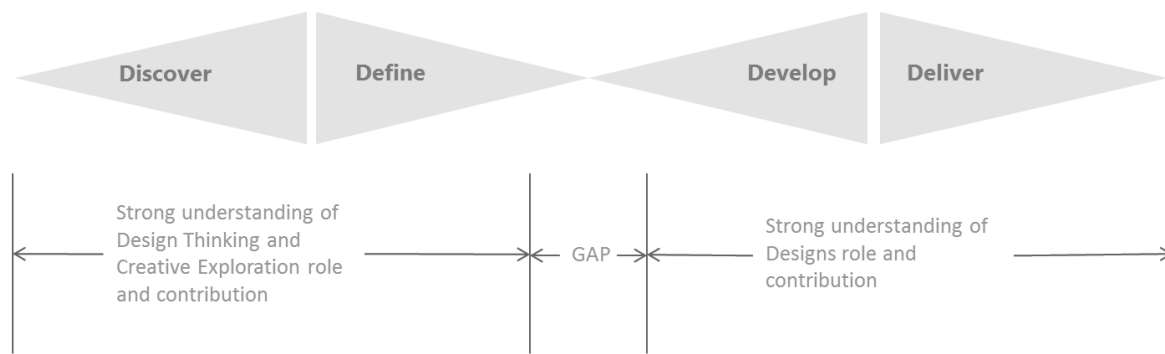

Figure 2. Decision Gap in the DDP

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 realisation 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 utilising the old 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' [11], 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 seminar discussion 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 [12], Desirability Competitive Positioning Model [13]. 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. The model uses criteria as identified during the Discover Phase, and through a combination of heuristic evaluation and user engagement stack ranks them in order of relevance to user needs. Each criteria is then given a minimum pass mark, 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. Each idea generated during the early Define Phase is then scored against the criteria. 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 centre is the winner. While numeric outcomes are sufficient to identify the winner, visualising the results was considered important to allow designers to relate to the outcome. Figure 3 shows example data, 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 4).
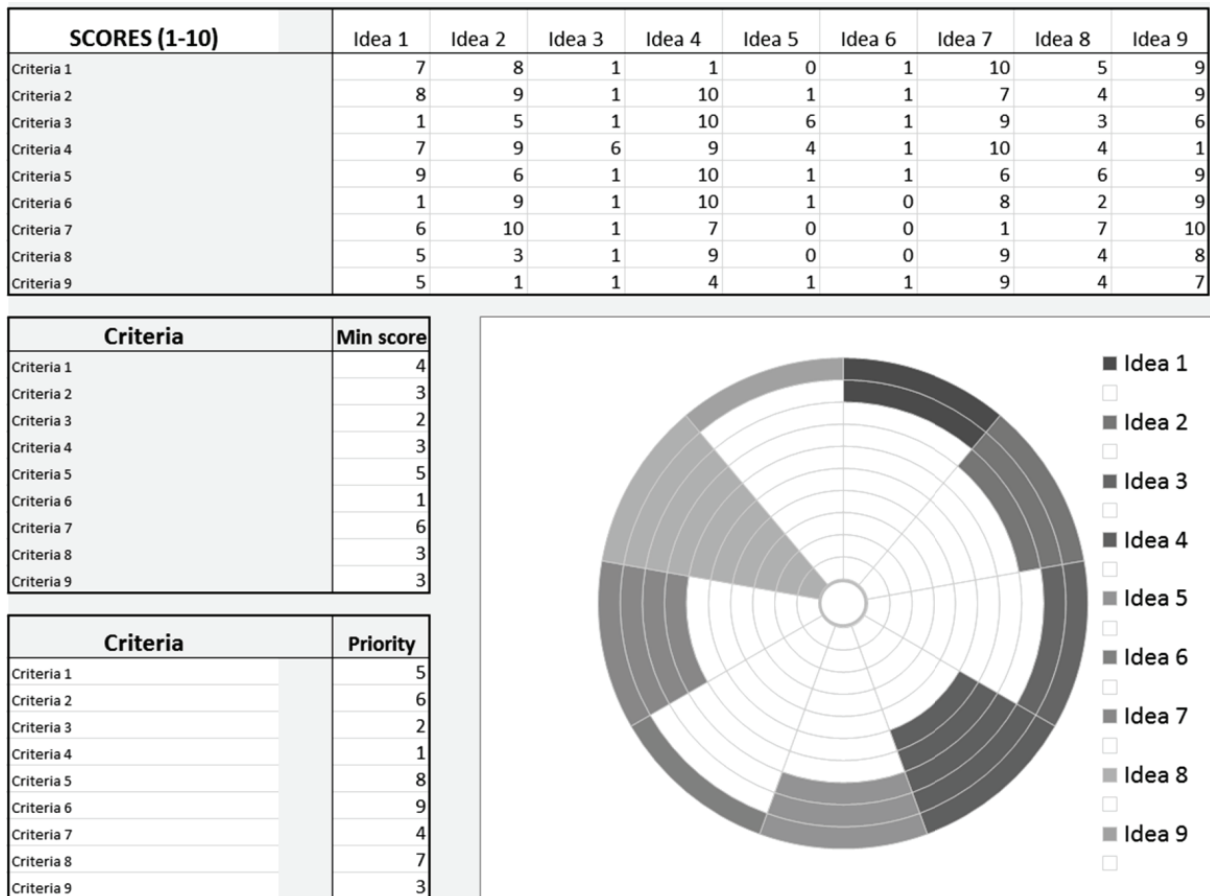
SCORES (1-10)	Idea 1	Idea 2	Idea 3	Idea 4	Idea 5	Idea 6	Idea 7	Idea 8	Idea 9
Criteria 1	7	8	1	1	0	1	10	5	9
Criteria 2	8	9	1	10	1	1	7	4	9
Criteria 3	1	5	1	10	6	1	9	3	6
Criteria 4	7	9	6	9	4	1	10	4	1
Criteria 5	9	6	1	10	1	1	6	6	9
Criteria 6	1	9	1	10	1	0	8	2	9
Criteria 7	6	10	1	7	0	0	1	7	10
Criteria 8	5	3	1	9	0	0	9	4	8
Criteria 9	5	1	1	4	1	1	9	4	7

Criteria	Min score
Criteria 1	4
Criteria 2	3
Criteria 3	2
Criteria 4	3
Criteria 5	5
Criteria 6	1
Criteria 7	6
Criteria 8	3
Criteria 9	3

Criteria	Priority
Criteria 1	5
Criteria 2	6
Criteria 3	2
Criteria 4	1
Criteria 5	8
Criteria 6	9
Criteria 7	4
Criteria 8	7
Criteria 9	3

Figure 3. Idea Filtering Analysis

The students used the tool and were asked to provide feedback on whether they found it useful in articulating their rationale and decision for which of their concept ideas deserved to progress to development.

The continuation of the project allowed student to refine concepts into practical design proposals, within the manufacturing limitations and possibilities of 3D Printing. This was in line with the Development stage of the DDP. Students were charged with using the tool/matrices given in their decision making pathway to validate their design selection. At the next formal meeting final proposals in the form of 2D Presentation were presented along with the completed tools/matrices.

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 goods 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 [2], [14], 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 key 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, these need to be explored further.

Building on these early observations more structured research is needed to explore the utilisation 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. While introducing the concepts to students there is also a potential gap within the practicing design profession to become quantifiable in decision making. 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 guideline that ensures the more qualitative aspects of project appraisal are given an equal weighting with the more conventional quantitative approaches, and seeks to identify opportunities for successful innovation that would otherwise have been overlooked.

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