Engineering Part IIB

Paper 4C4 - Design Methods

SUMMARY NOTES

Creative methods

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CREATIVITY

Creative design has always proved a difficult activity to define satisfactorily, and there have been many problems in establishing criteria by which it might be identified. Despite this, the literature on creativity and design often requires a creative idea to be recognized as both novel and appropriate. While different design activities demand or permit different levels of creativity, design solutions that are not immediately obvious from the problem statement must require the generation of novel and appropriate ideas, and must therefore require creativity. Creativity is consequently considered to be an important aspect of design performance and is the stated objective of much design education. As a contributor to product innovation, creative design is also a key determinant of many organisations' commercial success and of a nation's economic health.

Design progress within projects is often described in terms of suddenly emerging ideas that are variously termed "eureka events," "ah-ha moments," or "creative leaps." Such ideas may seemingly lack preparation or precedence but can subsequently define a new and fruitful direction for the project. While often considered obvious once they have been recognized, these sudden insights may appear to share little logical connection with previous solution attempts. One reason that these moments of insight are necessary at all is because designers confronted with a problem can assume or infer constraints that limit the solutions they explore. The boundaries of this exploration are expanded when the problem is reframed and designers learn to see things in new ways and to look for new kinds of solution. This suggests that sudden insights might not just relate to the production of creative solutions to a given problem, but also to the creative formulation of the problem itself. If what we require are new ways to view a situation, the question is how we might encourage or foster these insights. Thankfully, there are a number of methods that have been developed to help with this. Here we will concentrate on six of them:

1) Brainstorming
2) Six hats
3) 5WH
4) SCAMMPERR
5) Classifications
6) Attribute dependency

1. Brainstorming

Brainstorming is a popular approach to idea generation that was formalised in the 1930s but has presumably been used in one form or another since long before then. The method is predicated on two basic observations of traditional idea generation sessions. Firstly, it is observed that in many meetings ideas are generated and evaluated at the same time; evaluation tends to dominate in this process and therefore the generation of ideas is actually discouraged. Secondly, it is observed that where a large quantity of ideas are generated some high-quality ideas can be found; quality is therefore located in quantity. To overcome the first observation and to capitalise on the second, brainstorming sessions try to encourage the production of a large number of ideas and to defer judgement of those ideas until a later session. This uncritical production of ideas permits one idea to be built upon another even if that first idea would normally have been rejected as unrealistic or fanciful. Because such unrealistic or fanciful ideas can inspire other ideas that may well be more realistic and more useful, there is some benefit in retaining all the ideas that are generated and leaving the judgement of those ideas for a later time. This is somewhat like a virtuous circle, because a non-critical environment encourages the production of ideas that might not otherwise have been ventured.

Brainstorming sessions are often conducted in accordance with guidelines such as the following:

- Assemble a group of participants (4-8 people is typical)
- Clearly define the problem to be addressed. Avoid being too narrow or solution-focused
- Focus on quantity and variety of ideas (incl. the outrageous and unlikely)
- Piggy-backing of ideas is useful. Develop and extend the ideas of others
- • Move between different conceptual domains: literal, metaphorical, abstract, concrete, etc.
- Use visual, verbal and physical methods to express and develop ideas. Provide materials to assist with this
- Record and display ideas in a non-judgemental manner using visual, verbal and physical media
- When ideas dry up, try a new approach or re-pose the problem in a different way

- Once the session is no longer productive move to the relational phase. Relate ideas to each other in clusters (categorisation)

- Once the ideas are clustered evaluate them against some general criteria for success.

Whilst brainstorming is a popular and effective technique that is particularly widespread in the design world, it is also a technique that has some possible drawbacks. Firstly, because it takes place in a group setting it is not free from the group dynamics that can interfere with the effective performance of any meeting, and a poorly chaired session can be dominated by one or two individuals. This can result in an atmosphere which inhibits participation by some members. Secondly, although some combination of visual and verbal representations is useful, the method will often be oriented towards the visual/verbal preferences of the participants. Effective facilitation and chairing of a brainstorming session can reduce the influence of these effects.

Note: Brainstorming often plays a social role in organisations and recognising this can aid effective facilitation.

2. Six Hats

The *Six Hats* are a set of metaphorical hats that indicate thinking roles to be played by individuals or groups. Like brainstorming, the six hats method was formalised in response to observations of traditional decision-making processes. Unlike brainstorming, the objective here is to evaluate a proposal rather than to produce one. As such, it can be used during the evaluation phase that follows brainstorming.

In conventional decision-making processes, some group of stakeholders meet to discuss the options available to them and to contribute their views and expertise. These meetings often take the form of an argument, where a proposal is made by one stakeholder (or set of stakeholders) and that proposal is argued against by other members of the group. It is observed that one of the problems with such arguments is that they risk becoming highly irrational and ego-driven. Once people have adopted and declared their position, they tend to argue and defend that position rather than remain open to new information and counterarguments. The argument soon becomes a competition, and people become interested in winning the argument rather than reaching the best decision.

The six hats method is designed to exploit the natural competitiveness that occurs within meetings whilst reducing the effects of ego-driven decision-making. To do so, decision-making processes are divided into phases where everyone is asked to think in the same direction. For example, everyone might be asked to think positively about the proposal and any competitiveness is directed towards performance with respect to that objective. Everyone might then be asked to think negatively about the proposal, and again, any competitiveness is directed towards performance with respect to that new objective. In this way, those who make a proposal are encouraged to argue against it (along with everyone else) and those who are against a proposal are encouraged to defend it (again, along with everyone else). The collective intelligence and expertise of the group can therefore be systematically and sequentially aligned with different ways of thinking about the proposal. The objective is that the group come to appreciate the full complexity of a decision, and identify issues and opportunities that might otherwise not have been noticed.

The six hats are typically described as follows:

- *White*: neutral, balanced thinking. Focus on the data available. Ask what other data is needed
- *Red*: intuitive thinking. Permit people to reveal and use their gut reactions and emotions
- *Black*: cautious and defensive thinking. Look for potential problems or reasons that something might not work
- *Yellow*: optimistic and positive thinking. Look for reasons that something might succeed. Ask what might occur that would be helpful
- *Green*: deliberate creative thinking. Avoid criticism of ideas and encourage lateral thinking and freewheeling (see Brainstorming)
- *Blue*: overview and control. Often exerted by the chair (especially at the start and end), but can be used by anyone to request a hat change.

3. SCAMMPERR

SCAMMPERR is one of many checklists that are intended to provoke questions about how a product might be developed. The list encourages divergence in concept generation, and can be used either individually or in groups. It is often used as a stimulus in brainstorming sessions, especially when ideas begin to dry up.

With a particular design problem in mind, the SCAMMPERR list is used to sequentially consider the different ways in which a product or component might be altered. The list is typically presented as follows:

- *Substitute* – Ask how components, materials, people or processes might be substituted for each other or for something else

- *Combine* – Ask how things might be mixed, combined or integrated

- *Adapt* – Ask how you might alter, change the function, or use another part

- *Mag[/mi]nify* – Ask how a component or a product might be made bigger or smaller, or how you might add or subtract something

- *Modify* – Ask how you could change the shape, colour, texture or function of a component or product

- *Put to other use* – Ask how you might recycle or reuse some material

- *Eliminate* – Ask how you could remove or simplify something, or how you could reduce functionality

- *Rearrange* – Ask how you could change the order in which things are done or how you might swap components around

- *Reverse* – Ask how you could things turn inside out or upside down.

4. 5WH

5WH stands for "Who?, What?, When?, Where?, Why? and How?". Like the SCAMMPERR list, it is intended to provoke questions that expand the range of options or issues considered. Whatever aspect of the design challenge is being addressed, running through the list can prove helpful. For example, if a company was considering developing a new school chair for children, the following questions might spur on the research and development effort:

- Who will use it? Pupils? Teachers? Parents?

- What will they do with it? Sit on it? Stand on it rock on it? Prop doors open with it? Hang coats on it?

- When will it be used? For how many hours each day? For how many years?

- Where will it be used? Inside? Outside?

- Why will they use it? Are there alternatives that they might use? In what way is this chair better than the competition?

- How might it be stored? Stacked? How might it be moved? By trolley?

Considering these questions (and more) can help to illuminate aspects of the problem that have not previously been considered adequately. There is no correct set of issues that necessarily belong to each question, but collectively they often give a good general coverage of the problem to be addressed.

5. Classifications

Towards the end of the description of the brainstorming method it was suggested that ideas should be clustered and related to each other. This is really a process of *classification* (also referred to as 'categorisation', 'typology' or 'taxonomy'). Classification is useful in design when an individual or team want to collect ideas or issues together. It can help to make sense of a seemingly unstructured body of data; it can highlight gaps in thinking; and it can facilitate communication on complex issues. To offer a simple example of thinking through classifications, imagine a software company is trying to identify potential markets (i.e. different courses) for its automated course grading system. They might look to a university web site and find the university structured according to fields such as 'the arts', 'the humanities' and 'the sciences'. Any of these categories might be sub-divided further, for example by dividing 'the sciences' into 'the natural sciences' and 'the social sciences'.

If no pre-existing classification system is available for the domain that is being considered then one must be constructed. In constructing categories and sub-categories, it is worth noting that classes should ideally be:

- *Mutually exclusive*: items that fit into one category should not fit into another

- *Collectively exhaustive*: all the items should fit into one of the defined categories

- *Conceptually consistent*: all the items at a given level should be different from each other in similar ways.

In developing classifications, two related diagrammatic methods are useful:

- *Tree diagrams*: To construct a tree diagram, high-level categories and sub-categories are generated first and then they are populated with low-level instances. For example, with academic disciplines we would start with a high-level list of fields ('the arts', 'the humanities', 'the sciences', etc.) and seek to discover those low-level subjects that fit within each category (fig 1).

- *Affinity diagrams*: To construct an affinity diagram, ideas are first generated and then sorted into higher level categories. For example, with academic disciplines we would start with a low-level list of subjects ('chemistry', 'philosophy', 'anthropology', etc.) and seek to develop categories and sub-categories into which they might be sorted (fig 2).

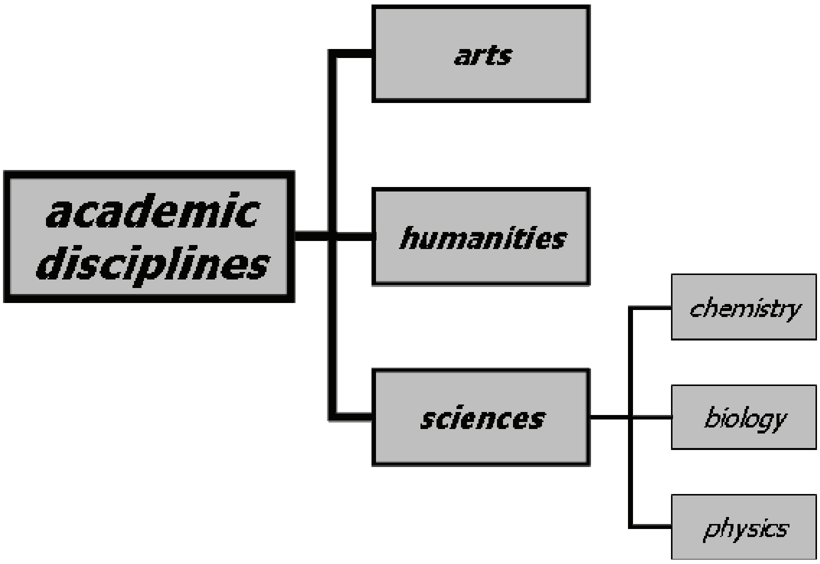

Fig 1 – A tree diagram of academic disciplines

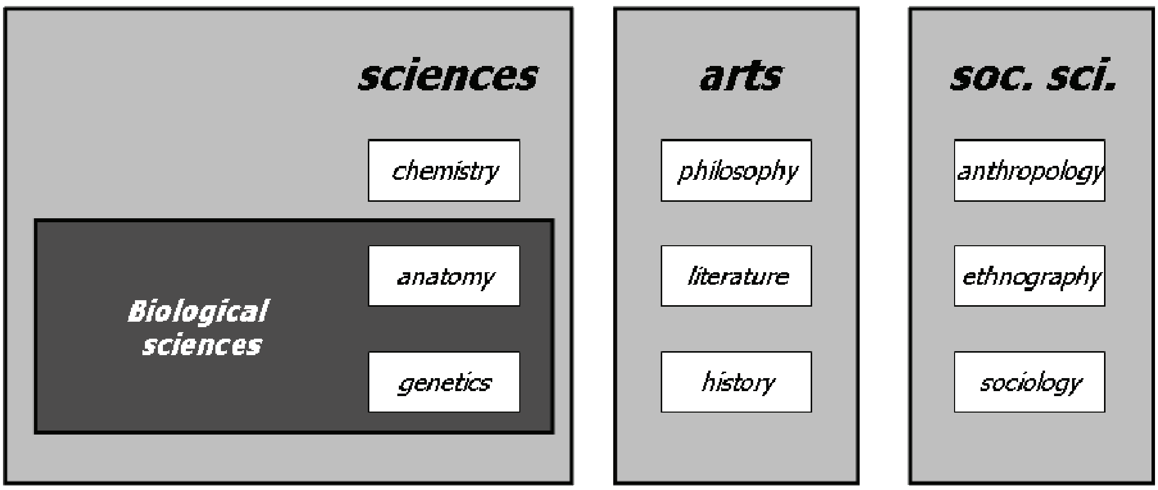

Fig 2 – An affinity diagram of academic disciplines

The structural (visual) difference between the tree diagrams and affinity diagrams is superficial; it is their method of construction that is important. In the first you move from general to specific, whilst in the second you move from specific to general. In practice, the two methods are often combined. Attempts to generate high-level categories are aided by considering low-level instances, and attempts to generate low-level instances are aided by considering high-level categories. As such, when people try to generate classifications, they often use tree and affinity diagrams at the same time. Classification systems are often subjective, because others might choose to divide up the domain of interest in some other way. However, they can still be a provocative stimulus to thought when attempting to comprehensively consider potential problems, potential solutions and potential markets.

6. Attribute dependency

Most of the methods described above aim to converge upon a solution to a given problem. The method of *attribute dependency* instead aims to generate solutions automatically and then find problems that those solutions actually solve. The method involves three basic steps:

1) Determine what dependencies exist between different system attributes

2) Explore what new dependencies might be possible

3) Discover what possible benefits the resulting designs might offer.

As an example of how such a process might be implemented, let's consider the problem of a company that makes paper cups. The method of attribute dependency might thus be as follows:

1) Pertinent attributes of the cup might be cup height, radius of base and radius of rim. The way in which the cup radius varies with height might be selected for examination (fig 3).

2) One possible variation on this relationship might to set the radius of the base to zero and to allow the radius to vary linearly with height up to a standard size at the rim (for drinking). This would result in a paper cup shaped like an ice-cream cone (fig 4).

3) Such a cup would not immediately seem to be particularly useful, but potential applications might include cups for selling drinks on the beach (so that they can be stuck into the sand for stability) or cups for children's medicine (to discourage them from putting the cups down until empty). With such potential markets identified further research and concept generation could follow.

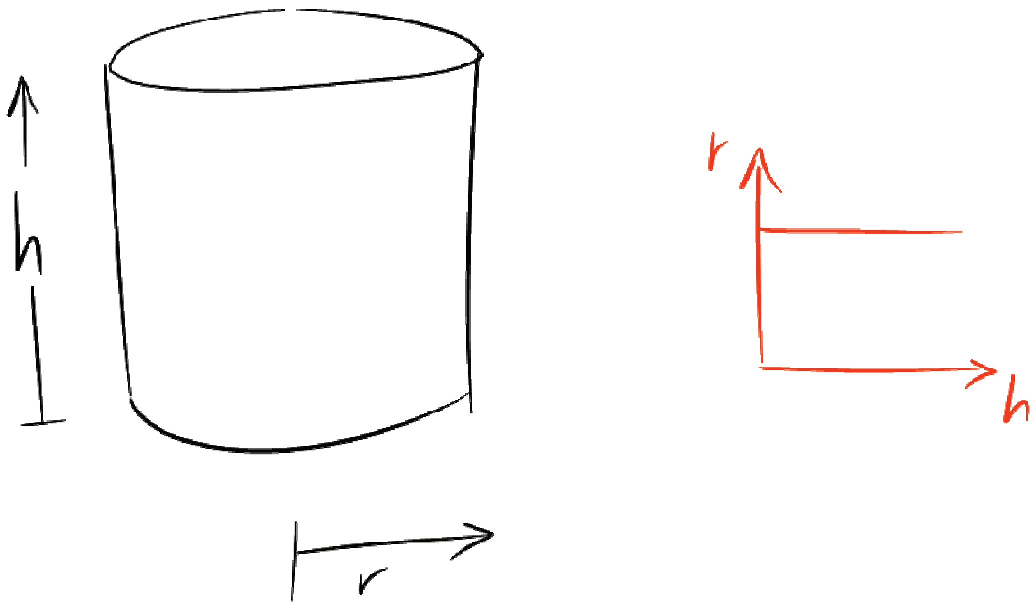

Fig 3 – Representation of attribute dependency for a cup

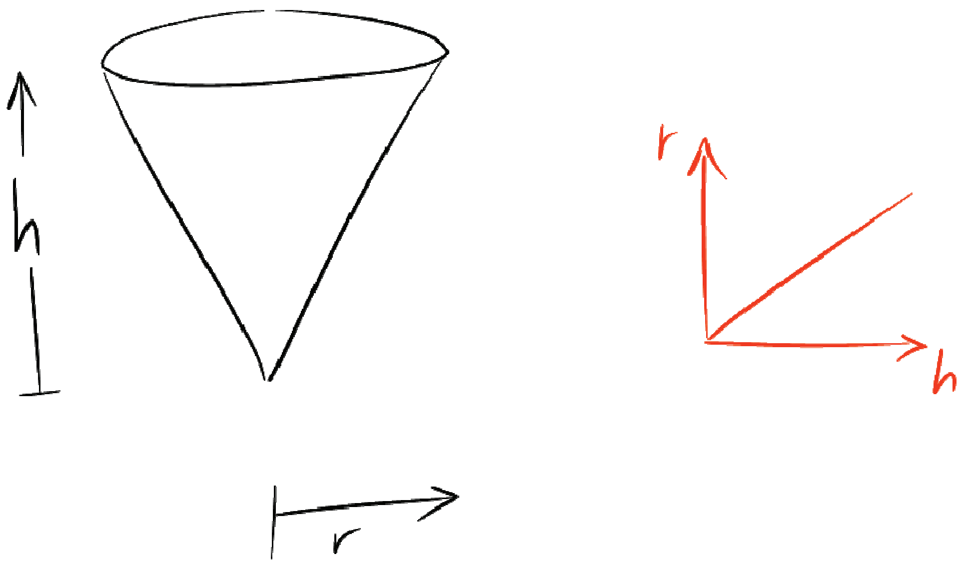

Fig 4 – Representation of a modified attribute dependency for a cup

7. Concluding notes

The different creative methods reviewed here can be used at various stages of the development process and can be used in combination with each other. They can also be adapted to best suit the problem being addressed and the context of application. In short, creative methods work best when they are creatively developed and applied.

8. Further reading

Osborn, Alex F. (1957) *Applied imagination: principles and procedures of creative problem-solving*. New York, NY: Scribner. [A classic text that describes variants of some of the methods described here]

Cross, N. (2000), *Engineering design methods: strategies for product design*, 3rd edition, Chichester, UK: Wiley. [Contains a brief discussion of creative methods]