# Observing creative behaviours

# Observing Creative Behaviours

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## Abstract

Sketching and 3D modelling have been long recognised as creative designing tools, but the role that CAD should play remains contested. Research by Charlesworth (2007) has suggested that CAD does not support creativity whereas findings by Robertson and Radcliffe (2008) imply that CAD when used with other design tools does enable creativity to be fostered. Prior research by the authors has shown evidence of creative behaviours whilst designing with CAD (Musta'amal *et al,* 2008a and 2008b). Potentially useful by-products of this research have been literature reviews concerning creative behaviours that have been reported by cognitive psychologists (Musta'amal *et al,* 2009 in-press) and also behaviours that have been reported by design researchers as being observed when 2D and 3D sketch modelling have been used.

The results of these literature reviews have been placed into categories. Seven categories of creative behaviours were adopted for the creative behaviours reported by cognitive psychologists. The 2D sketching behaviours have been placed in 8 categories and 3D sketch modelling reported into 3 categories. Data concerning these behaviours has been gathered using protocol analysis, interviews and diary methods on 4 design projects, including a project carried out by one of the authors.

This paper will describe the outcomes of the literature reviews and provide examples from design projects of the categories of reported creative behaviours. The potential usefulness of these categories for the observation of creative behaviours in classrooms and studios is discussed.

## Key words

Computer-aided Design (CAD), creative behaviour, 2D sketching behaviours, 3D sketch modelling

## Introduction

Designing has been recognised as the translation of human creative thinking through planned action in achieving preferred needs or desires. For example:

> To design is to plan for the making of something new. Designing entails generating, transforming, and refining descriptions and specifications of different aspects of a still non existent artefact and making the representations of it that enable communication and examination of the ideas involved, which ultimately enables the production or construction of the artefact. (Goldschmidt (1999:525):

For these reasons, designing is recognised as a creative process as it promotes the situation described as 'combining matrices of thought in our mind and our environment' (Warr & O'Neill, 2005: 119). It is this cognitive modelling activity which is central to designing (Archer, 1992; Dorst and Cross, 2001). Gero and Kannengiesser (2007:57) suggested that in the course of designing whenever a new design scheme is established creativity would occur. Although such events are not absolute indicators of the emergence of creative products, awareness and observation of them can increase our understanding of potentially creative behaviours.

Consequently, designing and creativity are closely related research agendas and many researchers had tried to explore the state of designers' minds when engaged with creative thinking, and particularly through cognitive psychology approaches (e.g. Nagai and Taura, 2006; Goel and Pirolli, 1992). They have attempted to understand the designers' thinking mechanisms with the hope of uncovering possible links to creativity. Various research methods have been used, and the interactions which occurred between designers and their designing tools has been part of their focused investigations e.g. sketching (Suwa and Tversky, 1997; Kavakli *et al,* 1998; Verstijneen *et al,* 1998), 3D modelling (Welch and Lim, 2000), Computer-aided Design (Robertson and Allen, 1993; Bhavnani *et al,* 1993; Robertson *et al,* 2007).

This paper discusses some evidence concerning observing creative behaviours whilst using CAD for designing and discusses the potential relevance of the methods adopted for observing creative behaviours in classrooms environments.

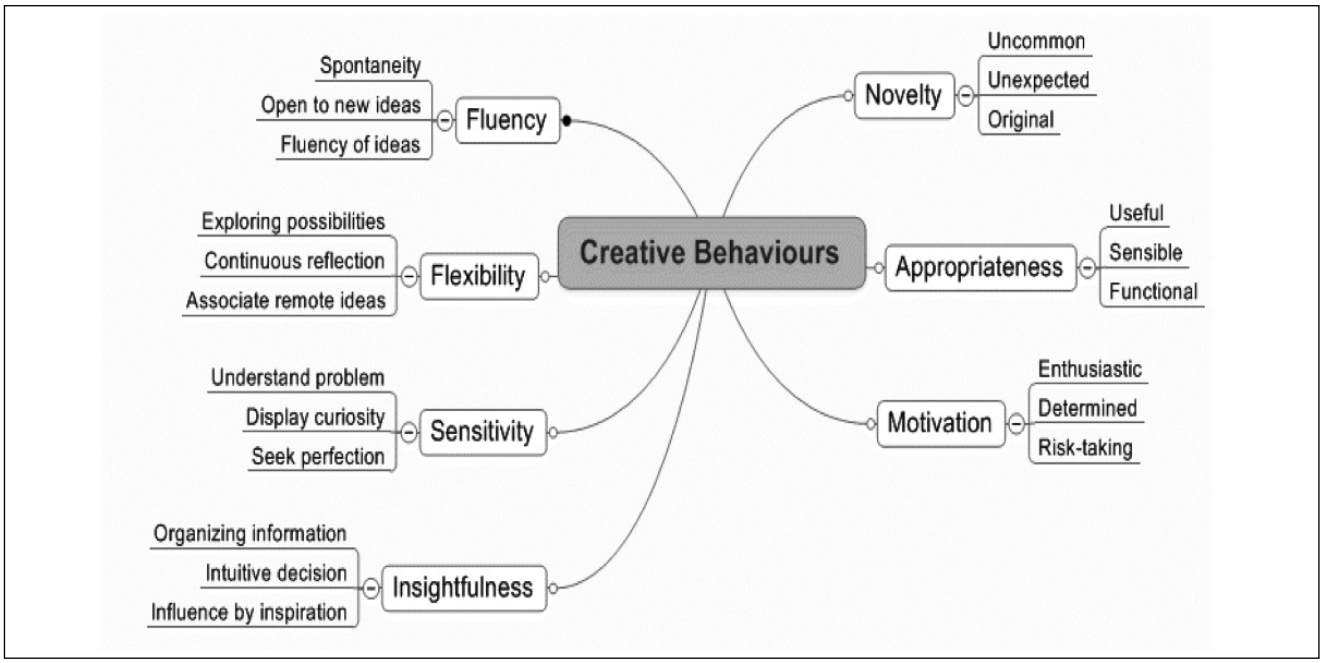


*Figure 1: Creative Behaviours Model*

## Creative behaviours model

A literature review was undertaken to distinguish creativity characteristics that had been suggested by prior researchers, particularly from the area of cognitive psychology (e.g. Cropley, 1967; Gilchrist, 1972; Amabile, 1983; De Bono, 1994; Balchin, 2005). A structured framework for creative behaviours was established as shown in Figure 1. The Creative Behaviours Model consists of seven categories which are *novelty, appropriateness, motivation, fluency, flexibility, sensitivity, and insightfulness*. Each category was assigned three descriptors to assist observations of the creative behaviours and the descriptions were presented in the authors' paper, which was published at the 2008 D&T Association Education and International Research Conference (Musta'amal *et al,* 2008a). A detailed account of this literature review is in press (Musta'amal *et al*, 2009).

## 2D sketching, and 3D sketch modelling behaviours framework

There is a considerable body of published work concerning the roles of 2D modelling such as sketching in supporting designing (e.g.Yang and Cham (2007), Kavakli *et al,* (1998), Rodgers *et al,* (2000) etc). 2D and 3D sketch modelling play vital roles in initiating and developing design ideas (Verstijnen *et al,* 1998a:520). Several researchers have reported modes of behaviour that they have observed when researching such modelling activities. These are shown in Tables 1 and 2.

Although these behaviours are not directly linked to creativity in the same way that the creative behaviours reported by cognitive psychologists are, 2D and 3D modelling are widely recognised as creative processes by design researchers and consequently some relationship may be inferred. However the primary discussion in this paper focuses on the Creative Behaviours Model directly derived from literature relating to creativity.

## Observing creative behaviours whilst designing via CAD

Modelling in 2-D and 3-D, both real and virtual, are recognised as key creative activities in designing (e.g. Tseng *et al,* 2002; Tovey, 1989). They play vital roles in externalising cognitive thinking as described by Archer (1992:8) i.e. modelling activities are 'external representations of ideas which were formulated and manipulated in the mind'. Such modelling provides rich information and explanation of the design not only to the designer but also to others. (Tovey 1989). In the context of CAD usage, the authors used the 'on-screen' design activity as the platform to observe and distinguish creative behaviours that were displayed by designers. The Creative Behaviours Model was used to categorise designing behaviours. Some of this evidence is presented in the next section.

| Reported behaviour categories | References | Examples of the authors' description of exhibited behaviours |
|---|---|---|
| Combining | Verstijnen *et al,* (1998b) | • Combined components into creative object without altering<br>• Manipulation of components:<br>- size variation,<br>- position,<br>- orientation |
| Restructuring | Verstijnen *et al,* (1998b) | Change or alter the structure of the original components such as:<br>• Size differences between components<br>• Embedding in other components<br>• Modification into different form<br>• Substraction |
| Lateral transformation | Goel (2001), Rodgers *et al,* (2000), McGown *et al,* (1998), Prats and Earl (2006) | • Obvious change of one idea to another different idea.<br>• Different form of solutions displayed<br>• Widening the problem space |
| Vertical transformation | Goel (2001), Rodgers *et al,* (2000), McGown *et al,* (1998), Prats and Earl (2006) | • Elaboration of existing idea into more detailed version.<br>• No modification of ideas, but clarification of neater lines and addition of dimension detail<br>• More detailed or refined version of the same idea |
| Part by part drawing | Tseng *et al*, (2002) | • Drawing a part completely |
| Non part by part drawing | Tseng *et al*, (2002) | • Incomplete drawing of a part |
| Reflective | Tano *et al,* (2003) | • Display slow sketch movement (e.g. Thinking, making comparison, decision making) |
| Experimental | Tano *et al,* (2003) | • Display fast sketch movement (e.g. Brainstorming) |

*Table 1: 2D sketching behaviours categories of behaviours*

| Reported behaviour categories | References | Examples of the authors' description of exhibited behaviours |
|---|---|---|
| Continuous modification and improvements | Welch & Lim (2000) | • Continuously incorporating modification and improvements into a solution |
| Sense of touch | Welch & Lim (2000), Molteni (1989), Rawson (1971), Bairstow *et al,* (2000), (Speight, 1983) | • Evaluate<br>• To pick things up and play with them<br>• Compose for making<br>• Seeing what a design looks like<br>• Able to feel the form |
| Adding and subtracting act | Molteni (1989), Bairstow *et al,* (2000) | • ….draw, cut, make indentation, add, raise …[clay] |

*Table 2: 3D sketch modelling categories of behaviours*

## Methods

### Samples

The data reported by Musta'amal *et al,* in 2008 was obtained by observing 4 masters design students. The examples shown below were taken from a personal design project undertaken by one of the researchers and three final year undergraduates in the Department of Design and Technology Department at Loughborough University.

### Procedure

The same methods as those reported in 2008 were used ie. a series of qualitative approaches comprising interviews, protocol analysis, and design diaries were carried out for data collection. In addition, Camtasia software was provided to each participant in order to enable CAD activities to be recorded without the researcher present. All video data were analysed using Transana 2.22, a qualitative analysis software for video and audio data as shown in Figure 2.

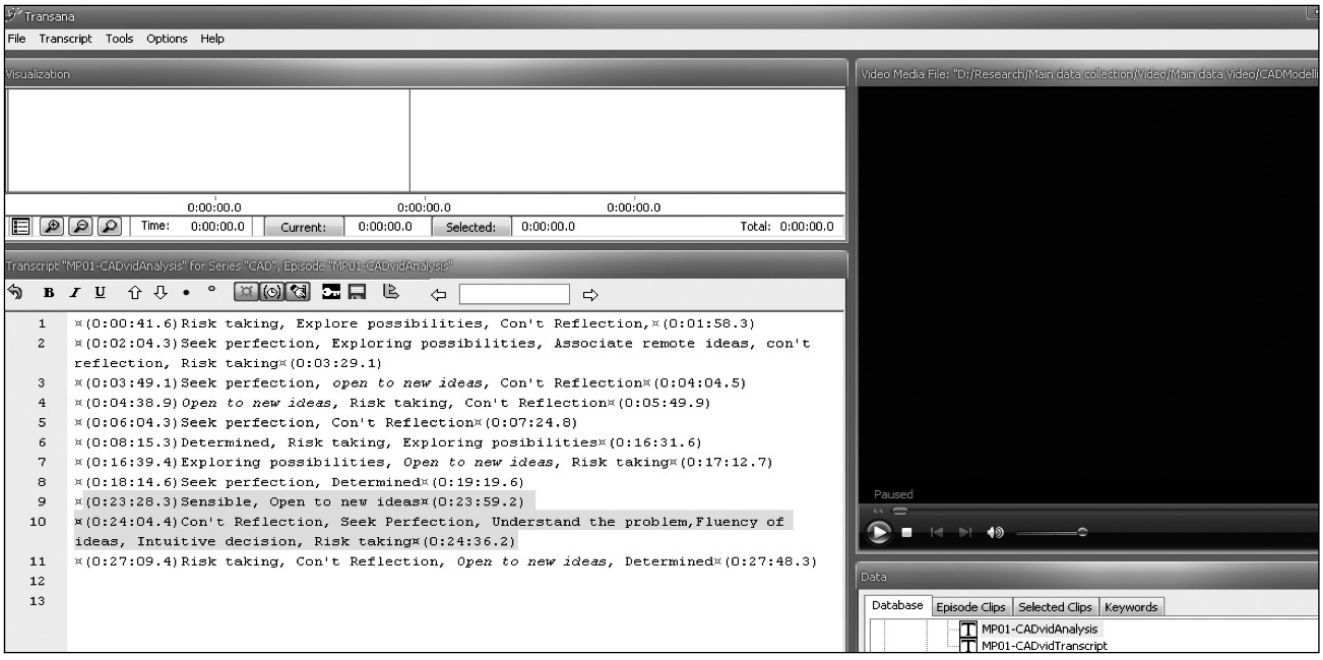


*Figure 2: Transana 2.22 analysis transcriptions page*

| Time (hr:min:sec) | Creative behaviours observed |
|---|---|
| (0:00:41.6)~(0:01:58.3) | Risk taking, Explore possibilities, Continuous Reflection |
| (0:02:04.3)~(0:03:29.1) | Seek perfection, Exploring possibilities, Associate remote ideas, con't reflection, Risk taking |
| (0:03:49.1)~(0:04:04.5) | Seek perfection, open to new ideas, Continuous Reflection |
| (0:04:38.9)~(0:05:49.9) | Open to new ideas, Risk taking, Continuous Reflection |
| (0:06:04.3)~(0:07:24.8) | Seek perfection, Continuous Reflection |
| (0:08:15.3)~(0:16:31.6) | Determined, Risk taking, Exploring posibilities |
| (0:16:39.4)~(0:17:12.7) | Exploring possibilities, Open to new ideas, Risk taking |
| (0:18:14.6)~(0:19:19.6) | Seek perfection, Determined |
| (0:23:28.3)~(0:23:59.2) | Sensible, Open to new ideas |
| (0:24:04.4)~(0:24:36.2) | Continuous Reflection, Seek Perfection, Understand the problem, Fluency of ideas, Intuitive decision, Risk taking |
| (0:27:09.4)~(0:27:48.3) | Risk taking, Continuous Reflection, Open to new ideas, Determined |

*Table 3: Creative behaviours descriptors observed from CAD modelling activity-MP01*

## Results

The results shown below were examples of findings from the data that has been analysed. Table 3 shows results from one of the participants' CAD designing activity. It was transferred from Transana databases's *Rich Text Format* files into tabulated form.

Table 4 shows examples of how the creative behaviours observed were interpreted based on the creative behaviours descriptors. Observations and interpretations were referred to on-screen CAD activities, which had been demonstrated by the research participants.

Tables 5 and 6 show examples of creative behaviours observed that could also be related to the reported categories of observed behaviours in relation to 2D and 3D sketch modelling.

### Discussion

The results again showed that creative behaviours could be observed and distinguished when participants were engaged with CAD activities. The Creative Behaviours Model facilitated the analysis process by providing an appropriate framework for recording behaviours observed when using CAD for designing. 'Novelty' is essentially related to the evaluation of design outcomes and would not therefore be expected to feature in

| Creative behaviours | Sample of behaviours observed | Event descriptions | Descriptor description |
|---|---|---|---|
| Novelty | - | - | - |
| Appropriateness | Sensible (0:23:28.3~0:23:59:2) | Make indent to make it much easier and comfortable for the finger to push the plunger down. Can see it from the virtual model (although need to clarify appropriate dimensions for the indent) | *Ability to suggest or make reasonable decision* |
| Motivation | Risk Taking (0:0:41.6~0:1:58.3) | Using ProE sketch feature to draw the syringe casing form without pre-set dimension. Just have a go, to see how it's going to look | *Not afraid to try new ideas and willing to cope with the consequences; have a go* |
| Fluency | Open to new ideas (0:04:38.9~0:05:49.9) | The shape didn't seem to fit with the syringe. Suggest to 'cut-off' the top part (to make it more presentable) | *Receptive to new ideas and not only stick only to an idea; ready to elaborate further or make changes whenever possible* |
| Flexibility | Continuous reflection (0:0:41.6~0:1:58.3) | Change the drawing from wireframe to solid and view the image from every angle to see its appearance | *Continuously evaluate and considering previous or present ideas or solutions* |
| Sensitivity | Seek perfection (0:18:14.6 ~ 0:19:19.6) | Not quite satisfied with the top-cut appearance. Keep trying to make it look better (change the modelling feature from shell to solid) | *The act of perfecting previous or present ideas; not easily satisfied with present ideas* |
| Insightfulness | Intuitive decision (0:24:04.4~0:24:36.2) | Draw the indent for the plunger's button to slide on. Did not have any measurement yet for it. Feel it might be useful to have another indent at the other side of the casing for the syringe retractor mechanism. Just make the indent of some dimensions and see if it looks as before | *Ability to come to a decision without being supported by valid or logical reasoning; make speculation or assumption* |

*Table 4: Examples of creative behaviours observed whilst using CAD (from participant MP01)*

| Start from<br>End time<br>(Hrs:mins:secs) | Examples of 2D sketching behaviours observed | Examples of creative behaviours observed |
|---|---|---|
| (0:04:18.4)~(0:06:43.4) | Restructuring (Size differences; Vertical Transformation (more details) | Exploring possibilities, Sensible, Seek Perfection, Continuous Reflection, Organizing Information |
| (0:07:02.4)~(0:07:37.4) | Vertical Transformation (more details), Experimental (Brainstorming), Non Part by Part, Reflective (Thinking) | Open to new ideas, Exploring possibilities |

*Table 5: Examples of 2D sketch behaviours observed (from personal design project activity)*

| Start from<br>End time<br>(Hrs:mins:secs) | Examples of 3D modelling behaviours observed | Examples of creative behaviours observed |
|---|---|---|
| (0:15:54.7)~(0:16:59.5) | Sense Of Touch: Evaluate, See, Feel, Pick up | Risk taking, Explore possibility, Sensible |
| (0:19:37.7)~(0:20:25.1) | Adding and substracting act: Draw, Cut out | Spontaneity, Risk Taking, |

*Table 6: Examples of 3D sketch behaviours observed (from MP01)*

data gathered during designing. (Once the novel features of the outcomes of the designing have been identified by stakeholders, the origins of those features can be tracked through the recorded data. This will be undertaken when the projects are completed and the results will be reported in a future paper).

The model has been used to analyse designers' behaviour whilst sketching, and undertaking 3D physical modelling in order to assess its capability in recognising creative behaviours within these design tools. The analysis showed that creative behaviours could also be observed and distinguished when using these design tools, as they had been when CAD was studied. This suggests that the Creative Behaviours Model provides a potentially useful framework for the observation of creative behaviours within at least these three modelling media. Such a framework could prove useful in facilitating inexperienced teachers in observing creative behaviours in classrooms and design studios, although this remains to be demonstrated. The suggestion would be that new teachers might well be supported in learning to observe creative behaviours in their students whilst they are designing by looking for indicators which fit the descriptions in the model.

Previous authors have suggested other categories of behaviours for observing 2-D sketching and 3-D modelling. Given that these modelling strategies have evolved alongside designing, it is credible assumption that all such modelling activities can be regarded as creative and teachers might well choose to look for all of them. However the examples shown in Tables 5 and 6 above also featured within the Creative Behaviours Model derived from literature associated with cognitive psychology and might therefore be particularly significant.

The sample of analysed data from 2-D sketching and 3-D modelling has provided supporting evidence for some of the reported behaviours that have been suggested by prior research. These frameworks provide the potential for structured strategies for the observation of these activities in designing.

## Conclusions

This research mainly focused on exploring the possible links between creativity, and in particular creative behaviours and CAD use in designing. In order to distinguish creative behaviours and facilitate the observation of such events, a framework has been established from a literature review. This framework has been used to capture the use of CAD in designing, and suggests evidence that CAD does promote creative behaviours. It has also proved possible to use the model to distinguish creative behaviours demonstrated by designers whilst engaged with sketching and 3D physical modelling activities.

These observations were made in relation to designing being undertaken by undergraduate and masters design, but other students and/or professional designers might be expected to exhibit similar patterns of behaviour. Creativity needs to be a key aspect of designing in general education and the creative behaviours model could support this goal by facilitating the structured observation of creative behaviours during designing. Hence, creativity assessment could be an aspect of systematic formative assessment carried out as designing takes place. It is likely that experienced teachers are already pursuing similar strategies to those indicated here, but their articulation is a key aspect of supporting those less experienced in developing effective classroom and studio practice in support of creative behaviours exhibited by their students.

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