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# CREATIVE BEHAVIOURS OBSERVED WHEN 2D AND 3D SKETCH MODELLING AND WHEN USING CAD MODELLING

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**ABSTRACT**
At E&PDE08, the authors presented a paper that demonstrated links between the use of computer-aided design (CAD) when designing and a 'creative behaviours model' derived from published research into creativity; primarily from researchers in the field of cognitive psychology. From a series of data collection approaches e.g. observations, protocol analysis, and design diaries, designers were found to display a number of creative behaviours whilst using CAD in designing [1]. Inevitably a key question arises as to how such creative behaviours relate to the behaviours observed when designers use other designing tools such as 2D and 3D sketch modelling. This paper will report the authors' initial research concerning this parallel agenda.
Literature reviews have been undertaken of reported categories of behaviours observed when 2D and 3D sketch modelling and a sample design project has been carried out. This provided data for an initial comparative analysis with the 'creative behaviours model' previously used in analysing CAD modelling. Again protocol analysis and design diaries were employed to record behaviours from 2D and 3D sketch modelling, and CAD modelling activities.
The design project has confirmed the emergence of most of the behaviours reported in the literature in relation to 2D and 3D sketch modelling. As 2D and 3D sketch modelling are accepted as creative activities when designing, there would be every expectation of correlation between the behaviours observed when undertaking these activities and the creative behaviours model derived from cognitive psychology. An analysis of the research results has been undertaken to reveal such correlations, as well as apparent differences.

*Keywords: Computer Aided Design (CAD), creative behaviours, protocol analysis, 2D and 3D sketch modelling, design project*

## 1 INTRODUCTION

Designing involves the mental formulation of future states of affairs and its product is the manifestation of the future possibility from the mind of a designer [2]. The abstract ideas, that exist loosely and unstructured in the designer's mind need to be externalized by transforming them to an understandable form for reflection and communication. This can be achieved by 2D and 3D sketch modelling and CAD modelling. Sketching and 3D sketch modelling have been long recognised as creative designing tools, but the role that CAD should play remains contested. Research by Charlesworth has suggested that CAD does not support creativity [3] whereas findings by Robertson and Radcliffe [4] 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 [1]. The creative behaviour model derived from literature published by cognitive psychologists had seven categories: novelty, appropriateness, motivation, fluency, flexibility, sensitivity, and insightfulness. Each of these behaviours was assigned with descriptors to enable any emergence of them to be observed and inferred as shown in Figure 1. This paper makes a further contribution by exploring and comparing the behaviours observed and reported when using 2D and 3D sketch modelling with the creative behaviours model previously used to analyse the use of CAD in designing.

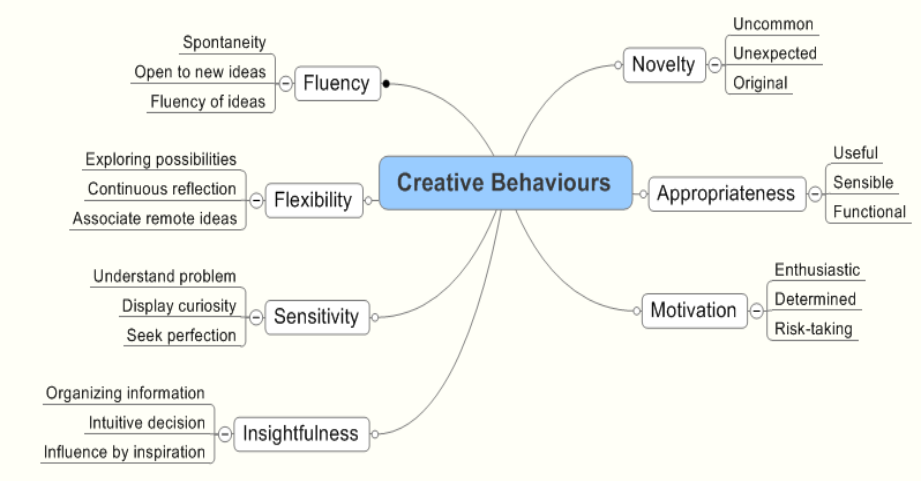


*Figure 1. Creative behaviours model*

## 2 2D AND 3D SKETCH MODELLING BEHAVIOURS

Literature reviews have been undertaken and reported categories of observed behaviours for 2D and 3D sketch modelling have been placed into categories as shown in Table 1 and Table 2.

*Table 1. 2D Sketching categories of behaviour identified in literature*

| **Reported behaviour categories** | **References** | **Examples of the authors' description of exhibited behaviours** |
|---|---|---|
| Combining | [5] | • Combined components into creative object without altering<br>• Manipulation of components:<br>o size variation,<br>o position,<br>o orientation |
| Restructuring | [5] | • 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 | [6], [7] , [8], [9] | • Obvious change of one idea to another different idea.<br>• Different form of solutions displayed<br>• Widening the problem space |
| Vertical transformation | [6], [7] , [8], [9] | • 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 | [10] | • Drawing a part completely |
| Non part by part drawing | [10] | • Incomplete drawing of a part |
| Reflective | [11] | • Display slow sketch movement (e.g. Thinking, making comparison, decision making) |
| Experimental | [11] | • Display fast sketch movement (e.g. Brainstorming) |

*Table 2. 3D Modelling categories of behaviour identified in literature*

| Reported behaviour categories | References | Examples of the authors' description of exhibited behaviours |
|---|---|---|
| Continuous modification and improvements | [12] | • Continuously incorporating modification and improvements into a solution |
| Sense of touch | [12], [13], [14], [15], [16] | • 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 | [13], [17] | • ….draw, cut, make indentation, add, raise…[clay] |

## 3 METHODS

Three case studies have been evaluated to investigate these categories. A personal design project was completed and two undergraduate finalist of Industrial Design were also involved as participants in this study. Protocol analyses were again employed to record behaviours apparent within 2D and 3D sketch modelling activities. In addition, design diaries were also filled-in everytime when CAD was used. These finding were used to provide an initial comparative analysis with the 'Creative behaviours model' previously used to analyse CAD modelling activities [1].

### 3.1 Case Studies

The personal design project related to music therapy and in addition to literature reviews, an interview was arranged with a music therapist, Liz Norman (www.soundconnection.org) to better understand the underlying issues in this area. The first undergraduate participant was undertaking a project related to self administered vaccination packs for people in remote areas. The second participant was designing a new concept for a musical instrument. During the design projects, a session of 2D sketching, 3D sketch modelling and CAD modelling were video recorded for later analysis. Design diary entries were also filled in by all the participants each time CAD was used to record the emergence of any creative behaviours. The video data were analysed using *Transana*, a type of qualitative analysis software for video and audio data.

## 4 RESULTS

The video data were analysed based on the 2D and 3D sketching behaviour frameworks, and later using the creative behaviour framework within the same time frames. The creative behaviour framework had been used in prior study to observe CAD users' creative behaviours. Sample of results from the three case studies are shown in Table 3 and Table 4.

*Table 3. 2D Sketching data*

| Activity | Start End time (Hrs:mins:secs) | 2D Sketching behaviour framework | Creative behaviour framework (CAD) |
|---|---|---|---|
| 2D Sketching OD | (0:11:08.2) (0:12:21.0) | Vertical Transformation (more detailed..), Part by Part dwg | Flexibility (Con't Reflection), Appropriateness (Sensible, Functional), Fluency (Open to new ideas) |
| | (0:12:36.5) (0:13:22.6) | Vertical Transformation (more detailed..), Reflective (Thinking), | Appropriateness (sensible), Sensitivity (seek perfection), Flexibility (Con't reflection) |

| | | | |
|---|---|---|---|
| | | Non Part by Part dwg | |
| 2D Sketching MP01 | (0:01:29.0) (0:01:34.6) | Vertical Transformation (clarification of neater lines) | Insightfulness (organizing info.); Flexibility (Exp. Possib); Sensitivity (Understand problem) |
| | (0:02:30.8) (0:02:59.9) | Lateral Transformation (widening prob. Space) | Fluency (Spontaneity) |
| 2D Sketching MP03 | (0:02:54.0) (0:03:07.0) | Vertical Transformation (elaboration of existing idea into more detailed version) | Flexibility (Con't Reflection); Flexibility (Exp. Possib) |
| | (0:07:00.3) (0:07:34.2) | Reflective (Thinking) | Flexibility (Con't Reflection) |

*Table 4. 3D Sketch Modelling data*

| **Activity** | **Start from End time (Hrs:mins:secs)** | **3D sketch modeling behaviour framework** | **Creative behaviour framework (CAD)** |
|---|---|---|---|
| 3D Sketch Modelling OD | (0:06:18.5) (0:06:46.1) | Continuous modification and improvement (Con't improvement) | Appropriateness (functional); Flexibility (Con't reflection) |
| | (0:08:23.3) (0:08:26.3) | Sense of touch (Feel; See) | Flexibility (Con't Reflection), Appropriateness (Functional) |
| Sketch Modelling MP01 | (0:18:56.4) (0:19:28.1) | Sense Of Touch (Feel) | Flexibility (Exploring Possib.), Motivation (Risk taking) |
| | (0:19:37.7) (0:22:05.9) | Adding and Subtracting Act (Draw; Cut) | Fluency (Spontaneity), Motivation (Risk Taking) |
| Sketch Modelling MP03 | (0:01:02.8) (0:01:20.5) | Sense of Touch (See) | Sensitivity (Understand Prob.) |
| | (0:09:13.1) (0:10:04.2) | Sense of Touch (Feel; See; Evaluate) | Flexibility (Con't Reflection); Appropriateness (Useful); Appropriateness (Functional) |

Data from the 2008 paper [1] showed creative behaviours in six of the seven categories when using CAD. From 247 creative behaviours observed, 16% came under *Appropriatenes*, 22% *Motivation*, 7% *Fluency*, 24% *Flexibility* 23% *Sensitivity*, and 8% *Insightfulness*. No creative behaviours were identified within the *Novelty* category. The same trends of behaviours have been observed in this study, and Table 5 below provides the sample of evidence from the 2009 case studies.

*Table 5. CAD Modelling data*

| **Activity** | **Start from End time (Hrs:mins:secs)** | **Creative behaviour framework [CAD]** |
|---|---|---|
| CAD Modelling OD | (0:18:18.5) (0:19:12.4) | Sensitivity (Seek perfection); Flexibility (Exp. Posib), Flexibility (Con't Reflection) |
| | (0:19:35.0) (0:19:50.0) | Sensitivity (Seek perfection) |

| | | |
|---|---|---|
| CAD Modelling MP01 | (0:06:04.3) (0:07:24.8) | Sensitivity (Seek perfection), Flexibility (Con't Reflection) |
| | (0:18:14.6) (0:19:19.6) | Sensitivity (Seek perfection), Motivation (Determined) |
| CAD Modelling MP03 | (0:03:22.1) (0:04:02.4) | Motivation (Risk taking); Flexibility (Exp.Possib.) |
| | (0:05:16.9) (0:05:50.5) | Appropriateness (Useful); Flexibility (Con't reflection); Fluency (Open to new ideas) |

## 5 DISCUSSION

The results have confirmed the emergence of most behaviour that was reported in the 2D and 3D sketch modelling literatures.

Table 3 and Table 4 show possible correlation in behaviours viewed as part of 2D and 3D sketch modelling, and the creative behaviours categories. Some of the results have shown some correlation between reported 2D and 3D sketch modelling behaviours and the creative behaviours model framework used to analyse CAD activity. To do this, video recordings of 2D and 3D sketch modelling were analysed, and the significance behaviours were further categorised using the behaviours criteria. The same events were re-analysed through the lense of the creative behaviours framework, and categorised based on the descriptors' description [1]. Some detailed examples from the 3D modelling results analysis are shown in Table 6.

*Table 6. Detailed examples of correlation identified between behaviour frameworks*

| **Activity** | **Start from End time (Hrs:mins:secs)** | **Correlations** | |
|---|---|---|---|
| | | **3D sketch Modelling behaviour** | **Creative behaviour (CAD)** |
| 3D sketch modelling OD | (0:05:58.1) (0:06:15.1) | Sense of touch (Feel; See) | Appropriateness (useful) |
| | (0:06:18.5) (0:06:46.1) | Continuous modification and improvements | Flexibility (Con't Reflection) |
| 3D sketch modelling MP01 | (0:18:56.4) (0:19:28.1) | Sense Of Touch (Feel) | Flexibility (Exploring Possib.); Motivation (Risk taking) |
| | (0:19:37.7) (0:20:25.1) | Adding and Subtracting Act (Draw; Cut) | Fluency (Spontaneity); Motivation (Risk-taking) |

Table 6 shows examples of correlation where there was clear evidence. As an example, in the event between (0:05:58.1~0:06:15.1) of 3D sketch modelling, the designer has been engaged with 'Sense of touch' behaviour when the designer tried to get the 'feel' about whether this basic shape is going to be comfortable by holding the model and at the same time rubbing the 'sounding pad'. When this event was re-analysed using the creative behaviour model framework, the designer has displayed an act of behaviour which falls under the 'appropriateness' category. The 'useful' behaviour has been displayed which shows emphasis on the intention of developing an ergonomically practical product design. The 'Sense of Touch' behaviour have shown the interconnection with the 'appropriateness' behaviour, where through the act of holding, and 'feel the form', the designer consciously attempted to suggest a constructive product design outcome.

## 6 CONCLUSIONS

This paper reports the authors' efforts to understand how design researchers identified and categorized designers' behaviour when engaged with 2D and 3D sketch modelling. Subsequently, 2D and 3D sketch modelling behaviour taxonomies were established and tested through a small number of design

projects. Since these methods are considered as part of the creative process in designing, this may suggest that these behaviours were indicators of creative behaviours. Analysing the emergence of these behaviours again through the 'lens' of the creative behaviours model has allowed comparison and possible links between some of them to be made. These findings have given a new perspective on how creativity can be perceived, and in particular, creative behaviours within different design modelling media. This pilot study suggests that the methods used to identify and compare creative behaviours in design modelling activities were effective. Further study with larger samples would provide greater insight surrounding creative activity when designing, and lead to objective means by which such activity can be used in the teaching and assessment of design.

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