

# Does CAD Really Encourage Creative Behaviours Amongst Its Users?: A Case Study

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## Abstract

Since the development of Computer-aided Design (CAD), it has been going through a rapid technological evolution in terms of its capabilities and use in designing. Its widespread adoption by designers has led to a range of views on the significant consequences it could bring for individual design ability and efficiency, and the quality of the output. It has been a long debate since its introduction whether CAD has any implications to creativity in designing. This paper describes a case study in exploring the potential on capturing designers' creative behaviours whilst engaged in CAD activity. A series of campaign have been undertaken to encourage as many participants as we can to participate in this study. Potential participants who are among final year students of Loughborough Design School (or previously known as Design and Technology Department) have been approached and briefed about this study. They have been explained on how they could participate and contribute in this study. Two undergraduate students who undertook their final year design project had volunteered to participate. The protocol analysis approach was employed to collect data in one of the CAD designing session by each participant where the time and venue it took place were pre-arranged. The Creative Behaviours Framework was used as a tool to capture the emergence of designers' creative behaviors. The video data were analysed using Transana software, and the findings were clarified through post-interviews with the participants. From the analysis and findings, the study suggests a link between the emergence of creative behaviours and the use of CAD in designing.

*Keywords:* Creativity, creative behaviours, protocol analysis, Computer Aided Design (CAD);

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## 1. Introduction

Computer-aided Design (CAD) has been going through a rapid technological evolution in terms of its capabilities, and roles in designing. Its widespread adoption by designers has led to a range of views on the significant consequences it could bring for individual design ability and efficiency, and the quality of the output. Spendlove and Hopper (2004: 2) suggested that CAD 'should therefore be seen as a set of tools, which can be adopted as and when they are appropriate within the broad creative process'. It has been a long debate since the introduction of CAD as to whether this software has any implications for creativity in designing (e.g. Robertson and Allen, 1991; Robertson and Radcliffe, 2008; Charlesworth, 2007). Although there have been indications that the research agendas concerning CAD and creativity are linked (Robertson and Radcliffe, 2008), there has been a lack of systematic efforts to articulate and clarify what the nature of the links might be (Lawson, 1999). This paper attempts to make a further contribution by undertaking a case study in exploring the potential for capturing designers' creative behaviours whilst engaged in CAD activity.

## 2. CAD and Creativity

Computer Aided Design (CAD) enables designers to graphically model their ideas on the screen as a complete design proposal. This technology, according to Hodgson (2006) improved the quality of student output in the form of visual images and product realisation. CAD is widely used in the design and engineering areas especially in product design and manufacturing. Zeid (2005) stated that CAD has been utilized in many ways including drafting,

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design, simulation, analysis, and manufacturing. It plays a great role, in designing including styling, conceptual design, simulation, product design, and detailed design etc. The increased use of digital media such as CAD to facilitate design activity has led to the need to consider what the impact it has on designers' performances. (e.g. Fraser and Hodgson, 2006, Bhavnani et al, 1993, Robertson and Allen, 1991).

There has always been a tension between designing and its associated technologies, and much debate about whether a knowledge supports or inhibits the designer. Due to this, Kimbell *et al* (2002) suggested that the impact of the use of CAD by designers could be sufficiently profound to warrant careful research. There have been growing concerns that using complex CAD software might have detrimental effects on user performance (e.g. ability, creativity, output), and Bhavnani *et al* (1993) studied these concerns in relation to three different levels of CAD users' experience (e.g. novice, regular, and expert). It has been known for some time that both the perceptions that users have of CAD systems and their expertise can significantly influence their performance. More recent studies have begun to look beyond the designer's performance with the CAD system itself towards its broader designing context (Charlesworth, 2007; Robertson *et al*, 2007).

The study by Charlesworth concluded that CAD 'has little or no value as a stimulus for ideas' (2007:35). It was claimed that CAD had less significance as a designing tool and suggested that it was only appropriate as a finishing tool to finalise design proposals. This implied that CAD is encouraging creativity in designing. Meanwhile, Lawson (1999) has made arguments on whether CAD would affect individual creativity through experiential examples from a number of architects. He implied that CAD could support designers in exploring design ideas and give freedom to visualise their creative imagination. Although expressing concern about the quality of the design outcomes, he clearly agreed that CAD enabled designers to produce 'convincing and original designs'.

### 3. Creative Behaviours Framework

Based on the published literature relating to cognitive psychology, a number of creative behaviours have been recognised (e.g. (Cropley 1967; Gilchrist 1972; Amabile 1983; De Bono 1994; Balchin 2005). These have been grouped into seven categories which are *novelty, appropriateness, motivation, fluency, flexibility, sensitivity, and insightfulness* as shown in Figure 1. No attempt has been made to select or rank these creative behaviours; they have simply been noted and classified. This framework was to be used to observe and capture such behaviours that had been previously reported by cognitive psychologists. The help in explaining the meaning of the seven terms chosen, each of the creative behaviours was assigned three descriptors.

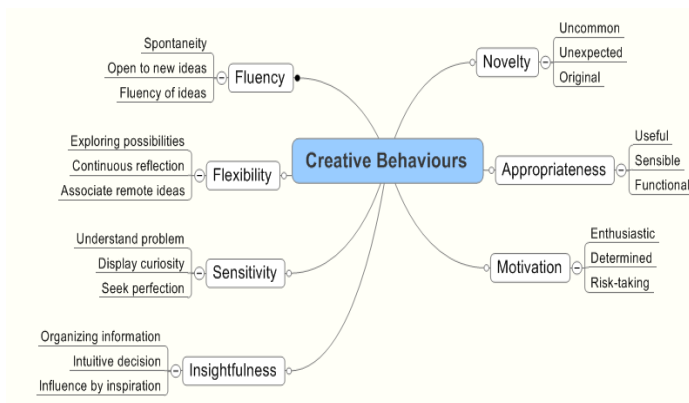


Figure 1: Creative Behaviours Framework

#### 4. Methods

An appropriate research strategy, in this context, would allow useful data to be captured while designers were engaged with CAD for designing. Designers illustrate their design thinking through modelling (e.g. 2D sketching, 3D sketch modelling, CAD modelling) with design outcomes being established as a result of such interactions. Since the relationship of CAD and creativity represents a complex research agenda, a case study approach was considered appropriate as it 'represents a disciplined mode of inquiry that can be organized around issues' (Smith and Strahan, 2004: 360). By definition, Blatter notes that 'a case study is a research approach in which one or a few instances of phenomena are studied in depth' (2008: 68). Case studies could provide descriptions of what CAD users, in particular industrial designer students do and say when using CAD during the act of designing.

In this context, protocol analysis was used in the data gathering undertaken through video recording by the researcher, and own on-screen video recording by the participants. The enthusiasm to capture and accurately describe design activity 'in the way designers experience it (Dorst & Dijkhuis, 1995: 264) has seen an increase in the number of research projects using protocol analysis as the research methodology (e.g. Gero and McNeil, 1998; Suwa *et al.*, 1998, Suwa and Tversky, 1997). Hayes (1986: 352) suggested that protocol analysis could be used 'to justify the use of verbal reports as data, especially as data regarding thinking' as it is represented externally in designing (e.g. 2D sketching, 3D sketch modelling, CAD modelling). The reason for using a video recorder to record the designing events in CAD was to allow access to the data for future re-assessment or re-evaluation by the researcher whenever necessary.

##### 5.1 Participants

A series of campaign were undertaken to encourage as many participants as possible to participate in this study. Potential participants who were among the final year students of Loughborough Design School (or previously known as the Design and Technology Department) were approached, and briefed about this study. An explanation of how they could participate and contribute in this study was provided. Two undergraduates students who undertaking their final year design project volunteered to participate. This kind of sample recruitment falls under the purposive sampling type approach. Participants were carefully recruited to make sure the data collected was relevant (Palys, 2008). They were invited and recruited based on these factors: their CAD background and intending to use CAD in their project. The anonymity of the participants was protected by using alphanumeric pseudonyms (e.g. P01 for participant 01). Both participants were undertaking different projects which were self-administered vaccination packs for people in remote areas, and a new concept for a musical instrument.

##### 5.2 Procedures

The protocol analysis approach was undertaken to collect data in one of the CAD designing sessions carried out by each participant, and the time and venue where it was going to take place were pre-arranged. This approach was adopted in order to allow the participants to speak aloud about their design thinking and feelings while performing CAD activity.

Participants were also required to carry out their own on-screen videoing for at least one of their other CAD sessions using CAMTASIA software. The software has a recording feature that enables the on-screen CAD activity to be captured easily by the participants themselves. The aim was to gather data in less obtrusive surroundings to the participants as they would choose the sessions that were going to be recorded. The licensed software was provided by the Department of Design and Technology, Loughborough University to each of the participants in order to facilitate the data recording activity. The Creative Behaviours Framework was used as a tool to capture the emergence of designers' creative behaviours. The data, which was in the form of video recorded data were then transcribed, and analysed using Transana. The findings were then verified through post-interviews session with the

participants. The data were presented based on time of event and creative behaviours identified including the observation and verbalisation text if any.

## 6. Results and Discussions

The video data and the video transcriptions were analysed and some of the examples of the findings are shown in Table 1. The observation and interpretation were based on CAD activities demonstrated by the participants which were recorded by the researcher using a video recorder, or through on-screen recording by the participants using CAMTASIA software.

Table 1: Examples of creative behaviours identified excerpt from CAD data analysis

Participant	Time (Start~End)	Creative Behaviours (description)	Observation	Verbalisation (Text)
MP01	(0:23:28.3) ~ (0:26:01.1)	Motivation (Determined)	Look confidence	
		Motivation (Risk-taking)	Have a go with the slot creation	<i>'I don't have any measurement yet...Just to test the thing'</i>
		Flexibility (Continuous reflection)	Preview the current output	<i>'It here...like an indent for a finger as well as the button. It's the idea..obviously sizes needed finding'</i>
	(0:25:10.3) ~ (0:26:01.1)	Insightfulness (Organising information)	preview the current CAD model, and plasticene model image	
MP02	(0:04:55.9) ~ (0:07:08.1)	Fluency (Spontaneity)	haven't planned like this before	<i>'Which I haven't planned to do...it's just...I kind need that one...'</i>
		Appropriateness (Sensible)		
	(0:04:55.9) ~ (0:07:08.1)	Motivation (Risk taking)	have a go-to find the best dimension and position	<i>'..this is the best..kind of place to put them both when I look at...'</i>
		Flexibility (Exploring Possibilities)	playing with ideas-play around with the dimension to see what it looks like	

The analysis has identified six of the creative behaviours as shown in Table 2; all except *novelty*. The results showed the emergence of these behaviours through the identification of any descriptor from each of the categories. It was anticipated that the novelty behavior would be difficult to identify during designing, and this was suggested by Mustaamal *et al* (2009: 63) who stated that '*novelty* is essentially related to the evaluation of design outcomes and would not therefore be expected to feature in data gathered during designing'. The discussion of how *novelty* could be identified and captured in the designing process will be presented in future publication. From the data analysis, in total 110 creative behaviours descriptors were captured when the designers engaged in CAD activities. The Creative Behaviours Framework has shown its capability in facilitating the observation and the identification of creative behaviours when the designers were using CAD for designing.

Table 2: Creative behaviours identified from participants' CAD activities

Creative Behaviours	Design Activity	CAD				Total
	Participant	P01		P02		
	Descriptor	CADvid	CADcam	CADvid	CADcam	
Novelty	Uncommon/unexpected/original	0	0	0	0	0

Appropriateness	useful	1	0	1	0	2
	sensible	0	2	1	0	3
	functional	1	0	0	0	1
Motivation	enthusiastic	0	0	0	1	1
	determined	3	2	2	0	7
	risk-taking	5	3	5	3	16
Fluency	Spontaneity	0	2	1	1	4
	open to new ideas	3	1	2	1	7
	fluency of ideas	0	0	0	1	1
Flexibility	exploring possibilities	4	3	5	3	15
	continuous reflection	7	7	11	2	27
	associate remote ideas	0	1	0	0	1
Sensitivity	understand problem	0	0	1	0	1
	display curiosity	0	0	1	0	1
	seek perfection	4	6	5	3	18
Insightfulness	organizing information	2	0	0	0	2
	intuitive decision	3	0	0	0	3
	<b>Total</b>	<b>33</b>	<b>27</b>	<b>35</b>	<b>15</b>	<b>110</b>

Notes: CADVid – CAD activities video recording  
 CADCam – CAD activities recording using Camtasia software.

## 7. Conclusions

This study attempted to provide empirical evidence on the potential links between CAD and creativity when designing. The data were gathered through a qualitative research approach which was protocol analysis of case studies undertaken within an industrial design undergraduate programme. From the analysis and findings, the study suggests link between the emergence of creative behaviours and the use of CAD in designing. This was supported by the emergence of creative behaviours descriptors except for the novelty descriptors. This was probably due to data gathering and analysis methods used in this study being unable to capture these descriptors. Further research is needed to explore this issue. As a conclusion, the research has provided indications that CAD might potentially encourage creativity in designing.

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