Computers as the Sole Design Tool: The Mackintosh Experiment

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Abstract

This paper reports on the findings of an empirical investigation into the use of the computer as the only design media in solving a design problem. Several 1st and 2nd year students took part in a two week experiment on the use of a CAD programme, AutoCAD 13 and AEC 5.0, to design a studio for a graphic designer.

Prior to the experiment an extensive literature search was carried out to explore the relationship between the design process, visual thinking, conventional sketching (interactive imagery) and Computer Aided Design. Out of this search a number of design variables were identified, developed and then tested through a series of observations and interviews with the students while they were engaged in the design of the Graphic Designer's Studio. Questionnaires were also administered to students to explore their views on issues including, using CAD instead of conventional tools, design areas where CAD is most effective, and how CAD can improve design skills.

The Statistical Package for Social Sciences (SPSS) was used to analyse students returns. Early results suggest that:

1. The way in which the computer helped students to translate their design concepts from 2D to 3D was quicker and easier than conventional media. The notion of shifting to and working in 3D proved very useful as students were able to investigate and explore the relationship between *form* and *space* and understand their spatial implications.

2. The time-scale for design decision making was influenced by the use of the computer which was found to speed up the decision making process in solving design problems.

3. A strong statistical correlation coefficient was obtained between the design output from CAD sessions and students' competence in terms of skills, attitudes and performance.

Design

Design is the distilled essence of the discipline of architecture. However there is also a great deal to the process of architecture that is not regarded as design. In school, design is a personal process whereas in practice it is viewed as a co-operative, even as a corporate, experience. Referring to Simon (1966), it could be argued that design is simple, only its environment is complex.

Design is often seen as the cognitive process by which a three dimensional form is generated. This process embodies so many intangible elements such as creativity, intuition and imagination which are essential to research as well. (Zeisel 1981) According to this author the nature of designing involves three activities: imaging, presenting and testing. His reliance on a linguistic rather than a cognitive definition of 'imaging' must be questioned. Also, to equate 'imaging' with 'real creativity', as he did, without a high level of abstract reasoning is misleading. But is there such a thing called 'creativity'? The paper shall return to this issue later.

A more elaborate definition of design came from Papanek (1971) who remarked that design 'is the conscious effort to impose meaningful order'.

According to Archer (1965) design involves a prescriptive model, intention of embodiment as hardware, and some sense of originality/creativity. In some definitions of design, logical process and scientific principles have also been incorporated within from the beginning. Fielden at al. (1963) defined design as: 'The use of scientific principles, technical information and imagination in the definition of a structure, machine or system to perform prespecified functions with the maximum economy and efficiency'. Hillier and Leaman (1974) suggest that design is the search for the appropriate transformation or unfolding of prestructures in relation to the constraints imposed by the environment of the problem. 'They conclude that if design method is to be improved then it is more important to study the environment itself than how designers design'.

One could argue that the act of designing incorporates three levels of activity: Attention-Sensation;

Perception-Conception; Conjecture-Appraisal

In defining the act of designing, one often encounters cognitive words such intuition and creativity which are difficult to apprehend. What is meant by creativity? Regarding the question of creativity, it is still clearly a mysterious and largely unknown process. It has been defined as the ability to bring something new into existence, (Barron 1965) a definition which Storr (1972) accepts as a reasonable one for 'the manner in which this process of creation comes about has been found so enthralling that millions of words have been written about it'.

Puzzling and mysterious it might be, one could claim that creative thinking is a product of past experience and knowledge as well as presumably an inherent talent. In his speech to the Academic Francaise in 1753, Buffon purported that 'the human mind can create nothing, and only produces after having been fertilised by experience and meditation, in that its perceptions are the germs of its products'. (Collins 1965)

Therefore, if one is not dealing with mediocrity, it is reasonable to conclude that the greater the knowledge and experience, the greater will be the possibility of a creative leap. (Newman 1990)

Developments in design methodology and process have attracted a great deal of research and attention from various workers, resulting in a number of design models. Despite the wide disagreement between researchers in terms of terminology in their models of the design process, the following model has some common ground:

Analytical Phase: [Programming]+[Data Collection]-(Observation, i.e. Inductive reasoning)
Creative Phase:[Analysis]+[Synthesis]+[Development]-(Evaluation, i.e. Deductive reasoning)
Executive Phase: [communication]-(Description, Translation, Transmission)

Design Research

While definitions for both design and architectural research existed in the literature, very few definitions for 'design research' were found after several searches. Design research can be regarded as a systematic inquiry that creates knowledge on the basis of design activity, the structure of design problems, and the management of the design process.

Literature on design research can be categorised under three headings: studies on 'tools'; studies on 'processes'; research on 'mediums'.

a) Studies on 'tools': works on sketching

This literature deals with the role of sketching in crystallising notions and forming ideas at the early design stage. The foundation for this research area were laid down by the pioneering work of Rudolf Arnhiem, from Harvard, whose publications are being used as textbooks by artists, designers and art psychologists. In ‘Visual Thinking’ (1970), Arnheim asserts that the separation between seeing/perceiving and thinking/reasoning is unreal and misleading. In ‘New Essays on the Psychology of Art’ (1986), Arnheim, through the works of three art psychologist gurus, explores the mechanisms of art perception and cognition and its relevance to Gestalt Psychology (a whole is more than or different from the sum of its parts). In ‘Art and Visual Perception’ (1954), he warns against art being drowned by talk, and remarked that ‘visual things cannot be expressed in words’ and ‘verbal analysis will paralyse intuitive creation and comprehension’.

Investigators of sketching such as Goldschmidt (1992) endeavours to make the literature on ‘visual perception’ relevant to architects by introducing the act of sketching as a third dimension to Arnheim’s two dimensions (of eye and brain) incorporated in ‘visual thinking’. The resultant relationship between the activities involved in sketching reads: active sketching (hand)Ô passive perception (eye) Ô active cognition (brain). She uses terms such as 'figural conceptualisation', to reiterate her rejection to any dichotomy between ‘concept’ and ‘figure’. Such terms, cut out of well established cognitive models and pasted in architectural drawing literature, cannot be fully understood without the context within which they have existed in the first place.

Recent work on the role of drawing in architecture (Lawson 1994; Fraser and Henmi 1994; Robbins 1994) claims that despite the use of CAD for the manipulating and editing drawing and for creating photorealistic images, animation and walkthroughs, conventional drawing methods are still preferred for creative design and design development.

The uniqueness of sketching as a design tool, as purported by many authors, might be an outdated concept. Recent work on the Electronic Cocktail Napkin, 'an experimental computer-based environment for sketching and diagramming in conceptual design' (Gross 1996), is an evidence that CAD can be used for sketching and creative design. The 'Drawing Analogies' CAD system (Yi-Luen Do and Gross 1995) is another example on how computers are currently invading the privacy of conventional sketching at the early design stage. This software is a shape based reminding programme that employs hand drawn sketches or keywords (i.e. 'architect= Scarpa AND place= Venice') to index and query visual databases.

The argument that regards both of diagramming/sketching and CAD as 'tools' can be questioned since CAD has some form of artificial intelligence, i.e. problem solving, while the sketch is merely comprised of unstructured marks on paper. The successful use of computers in education has forced the creation of CAL (computer aided learning) as a distinct field of knowledge. CAL packages have found a new role in education where human-computer interaction via the 'stimulus-response' dialogue, can release the creative potential of individuals and provide an environment for self-paced teaching and learning.

Finally it is useful to examine empirically, via applied research, how sketching can improve the act of designing.

b) Studies on cognitive 'processes': measuring the design behaviour

This group of studies attempts to investigate the design process by recording the designer's behaviour and his spoken thoughts using several techniques, one of which is the 'protocol' analysis. Introduced by Newell and Simon (1972), and adopted by many investigators, protocol analysis involves setting up quasi-laboratory experiments to record the behaviour of the designer using video-tape (Delft-XeroxPARC workshops- Akin), audio-tape (MIT Branch Library Design- William Porter), sketches on paper, etc.. The long-term objective of studies like Akin's (is to understand the intuitive design process using tools from cognitive psychology and making a series of subjective interpretations, arguments (figural and conceptual), and predictions. The validity and reliability of this type of study can be questioned on many grounds:

i) Mechanical and optical recording gathers data which are both relevant and irrelevant to the event under investigation. This makes the process of data analysis extremely difficult.

ii) Once they know they are being recorded, people show a different level of awareness and behaviour from everyday life. This casts strong doubts on the authenticity/validity of the event to be recorded.

More sophisticated studies of the cognitive strategies involved in architectural design have been reported in the literature. For instance, Lawson (1979) compared the performance of fifth year architecture students and fifth year science students in solving a design oriented problem. An on-line computer programme, capable of solving the problems, ran and monitored the experiment and compared the subject solution with the computer generated optimal solution. Analysis of subjects' protocols using statistical tests such as Kruskal-Wallis analysis of variance, revealed that most science students adopted a problem focusing strategy whereas most architecture students operated a solution focusing strategy.

c) Research on mediums: Computer Aided Design (CAD)

The origins of the theory behind CAD can be traced back to Aristotle's concept of a generative system that can provide a variety of potential solutions to a problem. (Mitchell 1977) Generative systems have been utilised in philosophy (the Lullian wheel), literary composition, musical composition, engineering design, and architectural design. Generative systems were systematically used by Lenardo da Vinci for the generation of central plan churches, and by Durand for the creation of plans, elevation and urban forms from different combination of building elements (columns, walls, etc.) (Madrazo, L. 1994). Classical architecture was also based on having a fixed vocabulary of architectural elements that can be assembled in different combinations to generate architectural forms. (Summerston 1963) A modern application of this principle can be found in Stiny's (1980) work on 'shape grammar' [generation of shapes and subshapes according to relational rules]. After defining the grammar, a computer can then be used to generate forms and objects in the corresponding language.

CAD is not a tool; CAD is a medium. It provides an environment to explore and test design ideas by means of interactive three dimensional solid modelling and visualisation. The addition of lighting, colour and texture maps enables the creation of photorealistic images more easily and more frequently during the design process than by hand. (Greenberg 1991) The visual modelling of acoustic behaviour of sound waves within enclosures, and the visual simulation of air movement using CFD (Computational Fluid Dynamics) programmes, are fascinating areas for further investigation. The ability to revisit cities and buildings lost to fire and/or destruction using visualisation techniques and virtual reality technologies, is an area with an immense impact on the study of architectural history.

The notion that computers can be employed in an innovative way in architectural practices has been reported in the literature. LeCuyer (1996) compared two different approaches to the creative use of computers in design by two world class architects. She remarked that 'while Gehry employs computers in design development, Eisenman uses computer-generated forms as his starting point'. Also recent books on computers in architecture (McCullogh et al 1991; Penz 1992) have shown that computers have changed the way design is being taught in schools and practised in offices.

Computers are currently having a new role in learning and teaching by the introduction of new CAL (Computer Aided Learning) packages for self-paced and distant learning. Working with traditional methods of paper and pencil, limits architecture students investigation of design mainly to 2D (plan, section, elevation), while employing CAD enables them to work mainly in interactive 3D (axonometric and perspective) as images are generated more quickly and more frequently.

d) Research on Design Methods

This type of research is concerned with the management of the 'design process' and the philosophy of 'design method'. It has attracted a great deal of attention from research scholars which led to the emergence during the 1960s and the 1970s of special research groups such as the 'Design Methods Group' in the UK and the 'Design Programming Group' in the USA .

Summary

To explore some of the issues outlined overleaf, this research has conducted a design problem solving experiment with some undergraduate students where the computer was employed as the sole medium for sketching, designing and presentation. All design crits were also carried out on the computer with the minimum use of conventional sketching (pencil and paper).

Design brief : A Studio For A Graphic Designer

Students were asked to design a studio in a garden site for a graphic designer according to the following design brief:

i) The studio is to have its own entrance so clients can gain access directly from the street and all necessary servicing must be made independently. At the same time access is to be provided through the garden from the house although it is not necessary for this link to be enclosed. A separate outside space is to be created as part of the new workplace.

ii) The studio must be designed to accommodate client meetings, the production of graphic work, general administration and a small display of finished work. The computer, VDU and printer, photographic stand, darkroom equipment, layout space, phone and fax are the graphic designer's most frequently used equipment and copious storage space is essential. A toilet and wash hand basin are also required together with general storage for coats and cleaning equipment. The total floor area of up to 40 square metres maximum is to be provided.

iii) Both natural and artificial light must be considered to create a pleasant working environment and some thought should be given to the way in which the studio will be heated and ventilated , as both issues will influence the form of the design proposal, the size and location of openings and the nature of heating and ventilating equipment.

The graphic designer has requested that the studio be visible from the street, and distinctive while being discrete. The entrance is to be clearly identifiable with a threshold that is welcoming and copes with the vagaries of the Scottish winter climate. While the interior is to meet its use requirements, be elegant and create an uplifting atmosphere. The 'skin' of the building between interior and the outside space is to be designed so that it can be in part, if not wholly, open up and take full advantage of good weather.

The Process

On the first day we introduced the research project. We explained to the student volunteers that we were running a short design workshop using 2D and 3D Autocad AEC as the only drawing and modelling tools and that it was not necessary to have any previous CAD experience. We made it clear that our purpose was to investigate the effectiveness of the computer as the sole development tool in the design process and that we were treating the experiment as open-ended research and had no fixed expectation of the outcome. We pointed out however that the students would have the opportunity to develop both their computing and design skills

The design programme was then introduced. This took the form of a general outline of the programme and the description of the requirements of the brief. A precedent, the Studio in Chislehurst Kent designed by Patel and Taylor, was used to illustrate how a small building had been placed and circulation organised on a site with similar but not identical characteristics and context as their own. By doing this we were able to discuss the issues of 'threshold' and 'route', entry and domain.

The students were then shown 'sketch' and other basic controls of AEC. Once these modes had been demonstrated they were given time to practice. Later in that afternoon everyone was asked to draw the site in three dimensions using AEC. This provided a scaled representation of the site context which could be used to explore, examine and develop design ideas.

At the start of the following morning a precedent studios talk was given. The aim was to stimulate thought about alternative organisational strategies that could be used. Three buildings each with different appreciates were described. They were all examined in relation to Louis Kahn's 'served and servant' concept. Bentham and Crouwel's 'relocatable house' in Almere of 1985 illustrated an 'Inhabited wall' service zone. Monarch's Leisure Studio in Finland of 1994 demonstrated the use of a 'free standing service core' placed within a simple volume to organise spaces of varying size. Ellen Dunham-Jones and W Jude Le Blanc's studio in Charlottesville, Virginia of 1992 showed how the served, service and circulation spaces could all be articulated separately. Although none of the examples chosen had the same brief and they all had different contexts we were able to abstract the essential conceptual and organisational ideas and also start to outline some different spatial and aesthetic approaches.

After this the introduction to AEC continued. The students were shown how to establish multiple windows on the screen each with a different viewpoint of the site. This allowed them the opportunity to see the implications of their proposals and any changes made simultaneously in plan, axonometric and perspective. They were taught how to select a viewport and zoom in on any chosen part of the drawing to examine or modify it. During the day they were also shown how to create walls, windows, doors, floors, columns and roofs.

The third day began in the computer room learning how to construct solids and openings in solids, making an animated walk through, creating layers, annotating and printing and plotting copies of drawings.

During the afternoon visits were made to the Architecture Department's darkroom and the Glasgow School of Art's Graphics Department. The intention was to see the type and size of equipment needed in a small darkroom and how it could be organised. The students also had the opportunity to ask a photographer about the pragmatics of developing photographs, the shortcomings of the existing layout and discuss more ideal arrangements.

In the Graphics Department they looked at equipment and existing layouts and talked to a designer who described the practicalities and ideal requirements of both the 'traditional' and computer aided graphic design processes. Fuelled with all these insights the students returned and continued to practice their newly gained skills and make some initial sketch ideas.

The next three days were set up as tutorial days when both computer and design lecturers were present as students explored initial ideas. The students were developing both their understanding and skill using the computer while at the same time exploring ideas. During this period we had asked them to use the library for further research and study of precedents. We also recommended a visit to the 'Twin Peaks' exhibition which was being held in the college. This was a show of 'creative excellence and business effectiveness in design and art'. The graphic imagery, layouts and products on display illustrated the nature of the work a graphic designer might be involved in and offered itself up as inspiration and additional potential design triggers.

We deliberately dissuaded the students from using any other means than the computer to form ideas so that we would be better able to assess the implications of designing with the computer only. This restricted them to the computer room and its hours of opening. If they were unable to contain themselves we asked them to bring in with them all other development work. Most however were able to work within the restriction. All tutorials were also given round the computer screen using either the simple sketch command or asking the student to modify their proposal in a specific way.

For the final three days of the design period the students were primarily working on their own with limited access to lecturers. Towards the end of the session a seminar was held to talk about how they might best describe their proposals. Different methods of using the VDUs effectively were discussed. They then had time to think about their presentation and make the necessary preparations.

Our reviews of the students' work were held in the computer room around the computer screen. Varied presentation formats were used. Some students conveyed their ideas using a sequence of views on screen including a 'walk through' animation, others subdivided the screen into multiple viewports and zoomed in on specific images as necessary or in response to a request for further information. The reviews were more interactive than usual and it was easier to identify the issue being discussed as the relevant image would be the focus on the screen.

General appraisal of the AEC programme and the computer hardware used in the research

programme.
AEC allows the designer to see his or her proposal in multiple views at the same time on the screen. These could quite easily include plan, section, elevation, axonometric and perspective side by side. This allows the designer to see the implications and potential of any design move more fully and in so doing open up options which might otherwise not have been so evident.

If a change or modification to a drawing is made it is made to all the drawings simultaneously so saving time adjusting each drawing separately. This theoretically allows more time to be spent on the refinement and development of the design.

It facilitates the creation of 3D shaded 'walk through which provide a better understanding of the nature of the building form and spaces being proposed. It also offers other insights into the spatial sequences and the experience they create and becomes much closer to the kinaesthetic experience of walking through a building. The next step would to be to link up to a virtual reality head set.

The option to create layers gives the designer the opportunity to produce additional degrees of information and detail. This in turn allows the designer to convey an idea fully or abstract specific information for further examination and development. It also reduces the need to duplicate drawings e.g. the essential idea can be conveyed using only linear presentation to asses the quality of the spatial organisation and form or additional layers could be used to show materiality, mass, transparency, colour, texture, use of natural light, denote size by dimension and describe activity and use with annotation or habitation with people and furniture and fittings.

If AEC is linked with other programmes i.e. structures, lighting and environmental management it would undoubtedly offer other design development and appraisal possibilities, many of which are already evident in architectural practice when architects and consultants work together and exchange information by E-mail.

As a linear design tool AEC is excellent. It demands that the designer make decisions to make the next drawn move. Without the decision there is no progress. Once the proposal/ modification/change is made it can be recorded and viewed in different ways and drawing systems simultaneously on the screen which allows a greater understanding of the design implications. These can then be appraised and the next move considered and made. The process of forces the pace of decision making and is ideal in a linear design development situation.

The AEC 'sketch' option has limitations as a means of drawing. The use of the mouse to draw free hand takes more time and demands far more control than pencil and paper. It does not have the range of thickness and intensity and it therefore cannot express the weight and emphasis intended in aspects of a drawn idea. The lack of fluidity hinders the range, speed and flow of drawing as a design tool in the initial stages when designers need the freedom to explore ideas. They need to be able to think laterally and work around an idea and take advantage of chance. With AEC the demand for a command to allow a progression to the next stage requires the designer to be constantly conscious of each decision. This I believe makes it more difficult to key into the subliminal and take advantage to the subconscious and serendipity.

There are scratch pads with digitises as well as VDUs which respond to light pens that are more responsive as drawing mediums and would have a closer resemblance with free hand drawing. This hardware and related programmes would have a closer affinity to the conventional design situation and might enable similar opportunities to maximise on the subconscious and unplanned

AEC has programmed in a range of built in geometric and type options. If a designer does not wish to work within this frame work he forfeits one of its advantages-speed of response. This is in effect a penalty and it may encourage the less ambitious to take the easy route and work within the given programme. To overcome this the designer has to have a greater level of skill to generate his own formal language and components and therefore has to be more determined and work harder. This is not necessarily uncommon in the design field as any designer who is pushing out the frontiers usually has to work harder in order to prove their ides and achieve.

The development of design and designing skills are encumbered if the designer is computer illiterate as such a large proportion of time is given to learning how to operate the AEC programme. This obviously can be overcome as the individual is given more computer training and time to develop and practice. If the computer is going to be used more as a design tool in the future them this skill base should occur earlier in training just as other communication skills like drawing and model making have been conventionally.

The computer room's internal environment is not a good conducive design atmosphere. This might be the case in many other institutions. External, contemplative views and reduced computer hum would dramatically improve the working conditions. It would be more desirable if the designer has space to display and refer to other inspirational and reference material. There is evidence that the messy desk syndrome and incidental conversation has great potential as design trigger and cross fertiliser of ideas.

Statistical Analysis with SPSS-PC

Questionnaires were administered to students and the response was collected and analysed statistically by SPSS-PC. A summary of the findings is presented as tables and bar charts.

The Frequencies of Students' Attendance, Gender and Age

	Student's Gender	
	Male	Female
	Student's Age	Student's Age
	Count	Count
18		1
19	1	2
20		4
21		1
22	1	1
23	1	
25		1
26	1	
32		1
Total	4	11

The table describes information about the students who took part in the experiment in terms of their number, gender and age. Although we started the experiment with 4 males and 11 females, during the first two days of the experiment only one male (25%) and five females (55%) have completed the experiment. This indicates that there was a higher attendance ratio amongst female students when compared to the attendance ratio amongst males. As to the factors that have contributed to this a number of assumptions can be put forward. It may be that the nature of the experiment was to encourage 'co-operative' rather than 'competitive' learning of CAD, something which failed to interest male students. The experiment examined several variables, most of which are presented in the Descriptive Statistics table. To test the mean difference in selected variables amongst the six students who completed the experiment, a Paired-Samples T-Test procedure was carried out (compare the means of two variables for the six students under two different states: before and after exposure to the CAD experiment). The use of this test can be justified on the basis that it is a powerful statistical test which produces results when one has a small sample size. (Clegg 1995)

Paired Sample T-Test for related samples

The paired samples statistics table displays descriptive statistics for the test variables, and followed by the correlation table which displays the relationship between the paired differences with a 95% confidence interval of the difference of the means. The following three tables represent the results of the t-test carried out on the five pairs of variables, indicating the students' attitude before and after the experiment.

The null hypothesis states that there is no behavioural differences amongst the six students who completed the CAD design work shop, before and after the experiment in the five areas of: the overall feeling about the use of CAD (from positive to negative on a 5-point scale); areas of CAD impact (sketching, 2D design, 3D design and presentation); who to instruct the CAD course (design tutor, CAD tutor, or both); CAD competence (in terms of skills, attitudes and performance, a 5-point scale); CAD preparation (sufficiently prepared to use CAD).

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Overall Feeling About using CAD/After	4.67	6	.52	.21
	Overall Feeling About using CAD	3.83	6	.41	.17
Pair 2	Areas of CAD Impact/After	7.33	6	3.33	1.36
	Areas of CAD Impact	6.50	6	2.59	1.06
Pair 3	Instruct CAD Course/After	3.00[a]	6	.00	.00
	Instruct CAD Course	3.00[a]	6	.00	.00
Pair 4	CAD Preparation /After	1.67	6	.52	.21
	CAD Preparation	1.83	6	.41	.17
Pair 5	CAD Competence/after	3.83	6	.75	.31
	CAD Competence	1.67	6	1.21	.49
Pair 6	Improve the design and attitude/After	1.00	6	.00	.00
	Improve the design and attitude	1.50	6	.84	.34

a. The correlation and t cannot be computed because the standard error of the difference is 0.

Paired Samples Correlations

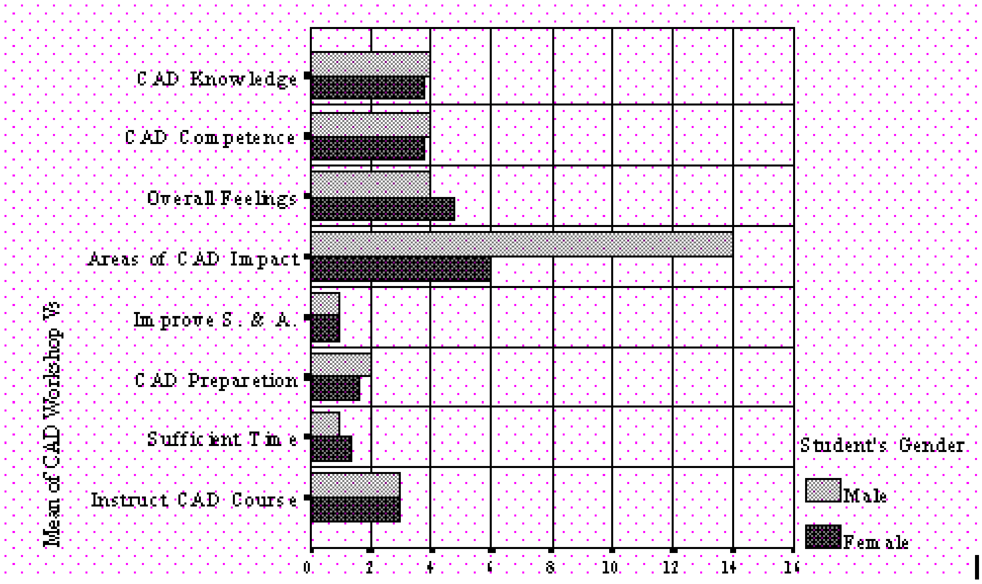
		N	Correlation	Sig.
Pair 1	Overall Feeling About using CAD/After & Overall Feeling About using CAD	6	.632	.178
Pair 2	Areas of CAD Impact/After & Areas of CAD Impact	6	-.093	.861
Pair 4	CAD Preparation /After & CAD Preparation	6	.632	.178
Pair 5	CAD Competence/after & CAD Competence	6	.804	.054
Pair 6	Improve the design and attitude /After & Improve the design and attitude	6	.	.

The table above shows that there is a strong evidence to suggest a significant positive correlation, which is significant at 0.05 between CAD competence before and after the exposure to the CAD experiment/workshop. This may indicate that there is an association between the participation in the CAD workshop and students' newly acquired competence in handling design problems through the computer. However, a negative weak correlation was found in the areas of CAD impact on the design studio criteria namely, time saving, 3D, 2D and presentation. This may be related to the fact that most students response on these areas was similar before and after the experiment. Other significant positive correlation was found in the overall feeling about suing CAD before and after the experiment.

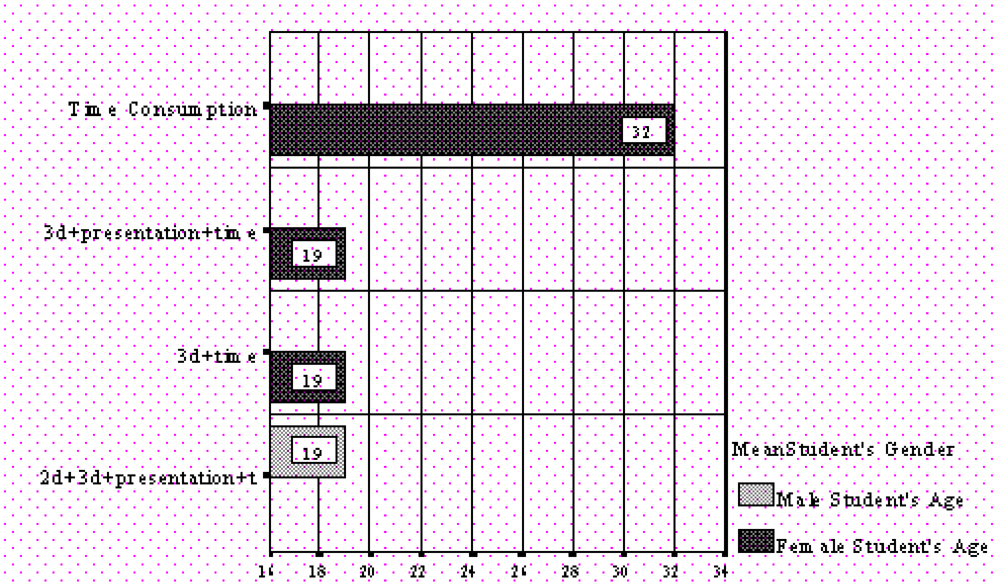
Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Overall Feeling About using CAD/After - Overall Feeling About using CAD	.83	.41	.17	.40	1.26	5.000	5	.004
Pair 2	Areas of CAD Impact/After - Areas of CAD Impact	.83	4.40	1.80	-3.78	5.45	.464	5	.662
Pair 4	CAD Preparation /After- CAD Preparation	-.17	.41	.17	-.60	.26	-1.000	5	.363
Pair 5	CAD Competence/After - CAD Competence	2.17	.75	.31	1.38	2.96	7.050	5	.001
Pair 6	Improve the design and attitude /After - Improve the design and attitude	-.50	.84	.34	-1.38	.38	-1.464	5	.203

The table above describes the results of the paired sample t-test carried out. The table indicates that t was significant in pair 1 & 5. So the null hypothesis can be rejected in these two areas: the overall feeling about using CAD and the CAD competence. As for improving the design and attitude or areas of CAD impact the hypothesis can not be rejected, thus there was no real impact from CAD workshop on these areas. Although as described in the descriptive table and the figures below , the impact should be clearly seen in selected part of these areas, and male student may have been influenced more than females in certain areas such as the CAD impact (figure below), and because of the small sample the male student did not have any real impact on the out come of the t-test carried out.



This chart implies that apart from the areas of CAD impact, the gender issue produced no significant difference in attitudes towards the various aspects of CAD and their implication on the design process.



The bar chart above gives some idea on the issues of gender and the design areas to which the application of CAD can produce positive results. The table below gives a summary of the descriptive statistics used for all the variables in this experiment.

Descriptive Statistics

	N	Range	Minim	Maxim	Mean	Std.	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
CAD Knowledge	6	1	3	4	3.83	.41	-2.449	.845
CAD Competence/after	6	2	3	5	3.83	.75	.313	.845
Overall Feeling About using CAD/After	6	1	4	5	4.67	.52	-.968	.845
Areas of CAD Impact/After	6	9	5	14	7.33	3.33	2.253	.845
Improve the design and attitude/After	6	0	1	1	1.00	.00	.	.
CAD Preparetion in CAD/After	6	1	1	2	1.67	.52	-.968	.845
Sufficient Time for CAD	6	1	1	2	1.33	.52	.968	.845
Instruct CAD Course/After	6	0	3	3	3.00	.00	.	.
CAD Competence	6	3	1	4	1.67	1.21	1.952	.845
Overall Feeling About using CAD	6	1	3	4	3.83	.41	-2.449	.845
Areas of CAD Impact	6	8	3	11	6.50	2.59	.830	.845
CAD Preparetion in CAD	6	1	1	2	1.83	.41	-2.449	.845
Instruct CAD Course	6	0	3	3	3.00	.00	.	.
Design Cometence	6	2	2	4	3.00	.89	.000	.845
Student's Gender	6	1	1	2	1.83	.41	-2.449	.845
Improve the design and attitude	6	2	1	3	1.50	.84	1.537	.845
No. of CAD Sessions	6	1	7	8	7.83	.41	-2.449	.845
No. of CAD Tarining Hours	6	1	3	4	3.83	.41	-2.449	.845
Student's Age	6	14	18	32	21.17	5.34	2.373	.845
Student's Number	6	5	1	6	3.50	1.87	.000	.845
Valid N (listwise)	6							

Conclusions

Due to the small sample size any conclusions that can be drawn from this study should be viewed with caution. However, an attempt is made here to summarise the findings.

As shown from the literature search ‘sketching’ proved to be a vital aspect of the act of designing. CAD programmes should therefore take this point on board and improve their ‘sketching’ environment, its commands and sub-menus. It was clear from the experiment that most students formulated and tested their design concepts during the initial design stage, and to do so they needed to use the ‘sketch’ command in AEC which proved difficult to use and control.

The development of design and designing skills are encumbered if the designer is computer illiterate as such a large proportion of time is given to learning how to operate the AEC programme.
The Paired-Sample t-test (before and after the experiment) showed that after taking part in the experiment, students’ attitude towards CAD and its relation to the design process were different from those observed before the experiment. The ‘overall feeling about CAD’ and ‘the newly acquired competence in CAD’ were the two areas where a significant difference was observed.
Most students felt that CAD software is a useful tool for 2D and 3D design and presentation. They also highlighted the potential of CAD packages for object editing and manipulation which can save time.

Finally, it is hoped that this paper has gone some way in formulating a ‘framework’ within which the problems of using the computer as the only design tool, can be addressed. Also, it is evident that there is a need for further ‘applied research’ into this area where objective techniques of data gathering, data handling, and statistical analysis can be exploited and employed further.

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