

## THE POSSIBLE ROLE OF CAAD SYSTEMS IN INITIATING INNOVATION IN THE DESIGN STUDIO

BHZAD SIDAWI

*College of Architecture and Planning, University of Dammam, KSA  
Email address: Bsidawi@ud.edu.sa*

**Abstract.** Design is a social phenomenon and the previous research highlights that design precedents and social interaction between designers including negotiation, collaboration and communications is essential to initiate creativity and the production of innovative design products. CAAD systems aim is to help the architect in formulating and developing design ideas. Researchers suggest that knowledge based systems can be integrated with CAAD systems so it would provide the architect with design knowledge that would him/ her to recall design precedents/ solutions thus link it to the design problems. Nevertheless, CAAD systems can provide limited help regarding the production of innovative design. Furthermore, the attention of the designers of knowledge based systems is focused on architects rather than the end product. On the other hand, most of the CAAD systems have web communication tools that enable designers to communicate their with colleagues and partners in business. However, none of these systems have the capability to capture useful knowledge from the design negotiations. Students of the third to fifth year at College of Architecture, University of Dammam were surveyed and interviewed to find out how far design tools, communications and resources would impact the production of innovative design projects. The survey results show that knowledge extracted from design negotiations would impact the innovative design outcome. It highlights also that present design precedents are not very helpful and design negotiations between students, tutors and other students are not documented thus fully incorporated into the design scheme. The paper argues that the future CAAD systems should be capable to recognize innovative design precedents, and incorporate knowledge that is resulted from design negotiations. This would help students to produce innovative design products.

## 1. Introduction

Architecture studio education involves a number of varied activities. Before the project begins, the tutor(s) may establish the goals, expectations, general procedure, and assessment criteria he/she will employ for the project. During each semester, tutors meet students either individually or in groups for design-related discussions and clarifications. The design studio should not be considered a safe haven - as one would imagine - as conflicts regarding design ideas are very likely to take place between students and tutors and between tutors themselves. This research is driven by growing complaints from the design studios' tutors and the discussions of the board of the Department of Architecture, College of Architecture, UoD about the low design abilities of students. Tutors from all academic levels repeatedly claim that students produce design projects but very few of them can actually produce innovative projects (The author 2009, Personal contact 2009). Previous research points out some possible causes of problems of the classroom teaching - in general- and design studio's teaching in specific. It indicates that in many instances, the teacher serves as the "fount of knowledge" and the students are the empty, open containers anxiously awaiting knowledge to be poured in. Other researchers such as Edmonds et al (1999), Fischer (2003), Mamykina (2002) and Shneiderman (2000) have put emphasis on collaboration, communication and how the social interaction/ dialogue would support/ initiate creativity. Kahvecioğlu (2007) suggests that the role of the studio instructor is to create an organizational style in studio education and this would help in developing creative strategies in the design studio. A number of approaches have been suggested to improve the design studio's teaching. It encourages educators to spark creative ideas, encourage follow-up of creative ideas, and evaluate and reward creative ideas (Sternberg& Lubart1991). Parkinson& Robertson (1999) suggest the Olympic Model that constitutes of personal and environmental components and this model can be used in establishing effective communications and development of creative individuals. On the other hand, researchers investigate the impact of CAAD tools on the production of innovative products and point out their potentiality to improve design skills of the designer and help in the producing innovative design products (Elkær 2009, Iordanova et al 2009, Kan& Gero 2008, Sosa et al 2002, Asanowicz 2008, Company 2009, Boland 2007). Nevertheless, the same literature shows that these CAAD systems still have limited capabilities regarding the production of innovative design products. Researchers suggest possible integration of knowledge based system, expert system, and/ or design cases database into CAAD system so these systems would provide the designer with specific and filtered design precedents. The knowledge based systems and databases focus on design cases, analysis,

problem/ solutions, constraints etc (Rosenman, Gero and Oxman 1992) but they are incapable to recognize/identify the innovative aspect'(s) of each design case. Furthermore, these systems concentrate on the architect rather on how to achieve an innovative design product (Reffat 2006). At present, web based and networked communication tools consists an integral part of many CAAD systems. For example, chat line, whereas communication is engaged in text mode, appears to support the development of richer design investigation through continuing development of ideas (Kvan and Gao, 2005). Virtual collaboration does not only enhance the design process but also changes the tools allowing designers to work together remotely or co-located (Reffat 2006). Nonetheless these systems still do not have the capability to extract the communications' outcome between participants and evaluate it regarding to certain innovation criteria, thus integrate and utilize it in the design scheme. This research explores design resources and communications factors that would hinder/ support the production of innovative design projects. It examines how these factors interact within the design studio's environment and how it can be implemented in CAAD systems. Therefore, the objectives of the research were set as the following:

- to explore students views about resources and tools that can be used to produce innovative projects;
- to find out communication routes and techniques that they use to get innovative ideas and feedback;
- to find out the hindrances and drivers for innovation in the design studio; and
- To suggest a CAAD prototype that would help in initiating innovation.

In regards to the research objectives, a combination of quantitative and qualitative research methods was used. The use of mixed methods is because the findings that relate to each method will be used to complement one another and to enhance theoretical or substantive completeness (Morse 1991). One hundred and ninety four students from College of Architecture and Planning, Years 3, 4 & 5 were targeted with a questionnaire that asks about tools, systems and conditions that would help in producing innovative products. Forty eight replied back which constitute 25% from the total number of targeted students.

Two software are used to analyze the data; SPSS 16 and AMOS. The following statistical tools were used to analyze the data: Mean calculation, and path co-efficient. Consecutively, nine students were interviewed. The target of the interviews is to validate the questionnaire survey results and clarify ambiguous points.

## **2. Creativity And The Architectural Design**

### **2.1. CREATIVITY AND CREATIVE DESIGN DEFINITION**

Creativity can be defined as the generation of ideas, which are a combination of two or more matrices of thought, which are considered unusual or new to the mind in which the ideas arose and are appropriate to the characteristics of a desired solution defined during the problem definition and preparation stage of the creative process (Warr 2007). Mumford (2003) defines creativity as the production of novel, useful products. In the fields of art and literature, originality is considered to be a sufficient condition for creativity, unlike other fields where both originality and appropriateness are necessary (Amabile, 1998, Sullivan and Harper 2009). So can we define creative architectural projects as the production of novel, useful and original architectural projects!. Such definition may look too general. Within the design studio context, the definition of creative architectural projects would be constrained/ featured by the goals/ objectives and prospected outcomes of the design studio course. Gero & Maher (1993) argue that ground breaking designs are those which possess innovative and creative qualities; and provide solutions that were previously unknown (innovative design) or subsequently produces entirely new products (creative design).

### **2.2. CREATIVITY AND THE DESIGN PRECEDENTS& COMMUNICATIONS**

The development of architectural project from initial concept to the end product is an interactive social and psychological process. Through this process, the designer negotiates various solutions to the design problem with oneself and communicates ideas with colleagues and instructors. The design process consists of a number of stages and these stages are linked with forward and reverse (backward) loops. Lawson (2006) points out that the design process is a simultaneous learning about the nature of the problem and the range of the possible solutions. The designer repeatedly evaluates and alters the design scheme and would return back to the previous stage or may be to the start stage to find out/ test a solution for the whole or a part of the design scheme. Lawson (2003) argues that experienced designers see some kind of underlying pattern or theme and made connections in a design situation (between design aspects) and also make a connection with some precedent in the episodic memory more than inexperienced designers. Expert designers acquire knowledge about solutions rather than necessarily about problems (Lawson 2003). This design approach style would initiate creativity as: "it is probably commonly accepted in design that creativity involves making use of solution ideas from apparently superficially different situations" (the same source). Gennari and Reddy (2000) describe the design

process as, ‘human activity, involving communication and creative thought among a group of participants’.

The literature review has very briefly highlighted the complexity of the creative design process and communications. Also, it illustrates the effect of a number of factors on the exchange of knowledge and development of creative abilities of students. This research tests the possible impact of personal qualities and social factors (i.e. student’s knowledge and design negotiations) on innovation in the design studios, third to fifth year, College of Architecture, University of Dammam. The field survey aim is to find out the most important factors and how they are linked and influence innovation in the design studio. This paper argues that the design of future CAAD systems should consider the incorporation of innovative design precedents and negotiations so it would be capable to initiate innovation. The next sections test the research hypotheses, demonstrate the results of the field survey and highlight how the proposed CAAD prototype should be designed to initiate innovation.

### **3. The field survey results**

#### **3.1. THE QUESTIONNAIRE SURVEY RESULTS**

Respondents consider the following tools as the most helpful in producing innovative projects and these are ranked according to their helpfulness (from more to less):

- the use of advanced rendering programs
- walkthroughs generated by the computer
- computer simulation of building behaviour, (e.g. thermal, environmental, users movement)
- partial 3D free hand sketching of the project or building
- smart White Board that is used for presentation and discussions
- standalone virtual reality
- full 3D sketching of the project or building
- web-based virtual reality
- immersive Virtual reality. Students have little knowledge about these systems as these are not available at the College of Architecture so they assume that these tools are not very helpful.

Respondents consider the following information resources as the most useful resources that help in producing innovative projects and these are ranked according to their usefulness (from more to less useful): instructor's feedback and advice; discussions with your colleagues from the same year; and the projects of higher year student's. Whereas they state that the following information resources are the least useful: projects of the same year students, the hard copy references and the electronic references at the

University library. The most frequent activities and communications of students that happen in the design studio during the term time are the followings:

- the generation of many sketches before making up mind when working on a design problem
- doing interactive and useful dialogue with instructors on how to reach to a creative design solution
- capturing innovative ideas of colleagues of the higher academic level from other departments
- not taking many risks because of the fear of failure

Whereas the least frequent activities and communications of students are:

- seeking the students and staff from different departments to help in solving specific design problems;
- capturing innovative ideas of the same academic year colleagues from different departments; and
- capturing innovative ideas from other departments' tutors

It seems that the design studio is governed mainly by two types of activities/behaviours. One of these seems positive which is the student's frequent use and integration of different communications activities and techniques to initiate creativity and innovation and the other seems negative which is the instructor dominance on the design process. Students state that instructors mostly encourage them to:

- do many trails to develop the design solution;
- follow various design approaches to reach to an innovative solution; and
- present a creative design solution

However, around one third of students state that strategies to motivate and initiate innovation are rarely applied in design studio and conflicts are hardly handled through constructive dialogue. The most frequent support that students get from the instructors is regarding the following cumbersome situations (arranged from more to less):

- the attempt to change the whole design solution during the design process;
- confusion over the nature and context of the design process;
- the attempt to change of the approach to the design solution during design process; and
- misunderstanding of some project requirements

The least frequent support that students get from the instructors is regarding the following cumbersome situations:

- low level of knowledge of students regarding one of the design aspects
- misapplication of one of the design requirements

Only co-efficient path relations that have significance value (i.e.<0.05) are reported here. The co-efficient path results show that when the frequency of tutor's support regarding some cumbersome design situations of the tutor increases, the student's performance (represented by the final grade) of the student improves. The results show that when the instructors encourage the student to follow various approaches to reach to an innovative solution more frequently, the student would be more able to proceed from one design stage to another smoothly and to make radical changes to the design solution. Also, when students do more interactive dialogue with their instructors on how to reach to a creative design solution and attempt – more frequently- to capture innovative ideas from colleagues in the same and higher academic level, they would be more able to: quickly understand the design problem, do quick analysis of the design problem, set quick conceptual design solution and to do fast appraisal of a design solution and their grades. Students who seek students and staff's help and capture innovative ideas of colleagues of the same academic level from different departments more frequently, would be more able to make radical changes to a design solution. Eventually, when design studio environment is govern with forgiving culture, patient with failure and trustful more frequently, the student would be able more to do quick analysis of the design problem, fast appraisal of a design solution, and proceed from one design stage to another design stage smoothly. On the other hand, the co-efficient path results revealed some odd results.

### 3.2. SUMMARY OF THE INTERVIEWS' RESULTS

The interviews has clarify some ambiguous points of the questionnaire's survey and provide deeper understanding to the possible factors that would impact innovation. These factors are grouped as the following:

#### **a. design resources**

Design precedents are necessary though they are useless without proper analysis of their negative/ positive features and innovative aspects

#### **b. the student's qualities**

- Students have little knowledge on how to design some architectural aspects of a project
- Some students are unwilling to collaborate with their tutors and have little trust of the tutor's design abilities
- Some students have Communication problems with their tutors as they do not know how to communicate with them; and
- During development of the design scheme, it appears that each party i.e. the tutor and the student have different imagination/ idea of what the final/ possible design solution/ outcome would be

#### **4. Brief Discussion Of The Field Survey Results**

This study -supported by the previous research- shows the role that CAAD systems play at present in initiating innovation and production of innovative projects at College of Architecture, UD. It also highlights the importance of design communications and design precedents in initiating innovation. The study found some negative factors that hinder innovation and these are related to the student's knowledge, communication abilities and communication problems with the tutor. This study argues that CAAD systems should be designed in a way that improves the students' knowledge and skills. The next section discusses the proposed design of a CAAD prototype.

#### **5. The Proposed CAAD Prototype**

The previous research highlight the shortages of the present CAAD systems. This paper suggests that factors which initiate the production of innovative design projects such as the design negotiations and design precedents should be incorporated as a module within CAAD systems. This module can be built on the concept of BIM, and is IFC (i.e. The Industry Foundation Classes) based. A BIM is a computer model database of building design information, which may also contain information about the building's design, construction, maintenance etc (GRAPHISOFT, 2003). This database is constructed with intelligent 'objects' which represent building elements. From this central database, different views of the information can be generated automatically; views that correspond to traditional design documents such as plans, sections, elevations, schedules etc. As the documents are derived from the same central database, they are all coordinated and accurate - any design changes made in the central model will be automatically reflected in the resultant drawings, ensuring a complete and consistent set of documentation (GRAPHISOFT, 2003). This module can be used to incorporate innovative design precedents and design negotiations into the design scheme. It would include the following (see figure 1):

- multi-dimensional knowledge base: a platform that stores innovative design examples from real life projects as well as from higher years' projects. It contains a Filter/ processor that analyze innovative precedents according to programmed innovative design criteria that would analyze how these precedents are designed, the design ideology, concept and methodology, what the innovative aspects are, how the design responds in an creative way to design constraints/ requirements and how they are linked to a specific design aspect i.e. form, function, order, aesthetics, structure etc. Also, the system would use similar system to BIM "clash detection" to scan architectural precedents and highlight the area of match

with the innovative design criteria. The system would compare the present criteria of the design scheme with the cases that are available in the knowledge base and evaluate how far one or more of the innovative components or the whole design can be used in the present design scheme. This would provide the student with an intelligent tool that would enable him/ her to choose and evaluate innovative design precedents thus implement it in the design scheme;

- digital storage and analysis centre that stores and analyse self-communications, Video-audio Communications or/and input from verbal communications with tutors and colleagues. This centre documents design negotiations; analyses and capture innovative bits/ ideas. Thus it would verify how far these ideas are relevant to the design scheme criteria;
- innovative decision support tool: multi-criteria decision analysis (MCDA) that weight the completed design scheme regarding to the given design criteria and that assess how far the present design scheme is innovative. As innovation is a qualitative aspect, the evaluation of certain idea should be based on a qualitative measurement. The assessment of qualitative criteria would be through the use of Analytic Hierarchy Process (AHP); and
- the system should be flexible in terms of allowing decision loops that simulate the design backwards and forward loops.

Such system would help students to look for innovative architecture, explore the innovative aspects (i.e. aesthetics, technical, structural etc) of the case studies, and to experiment several solutions and innovative ideas, making links between innovative design components and design ideas and feedback thus it may help in raising their awareness about innovative design products. Computer mediated communication would help students in getting wider feedback regarding the design scheme and would increase the student's knowledge about innovative solutions and how to incorporate it in the design scheme.

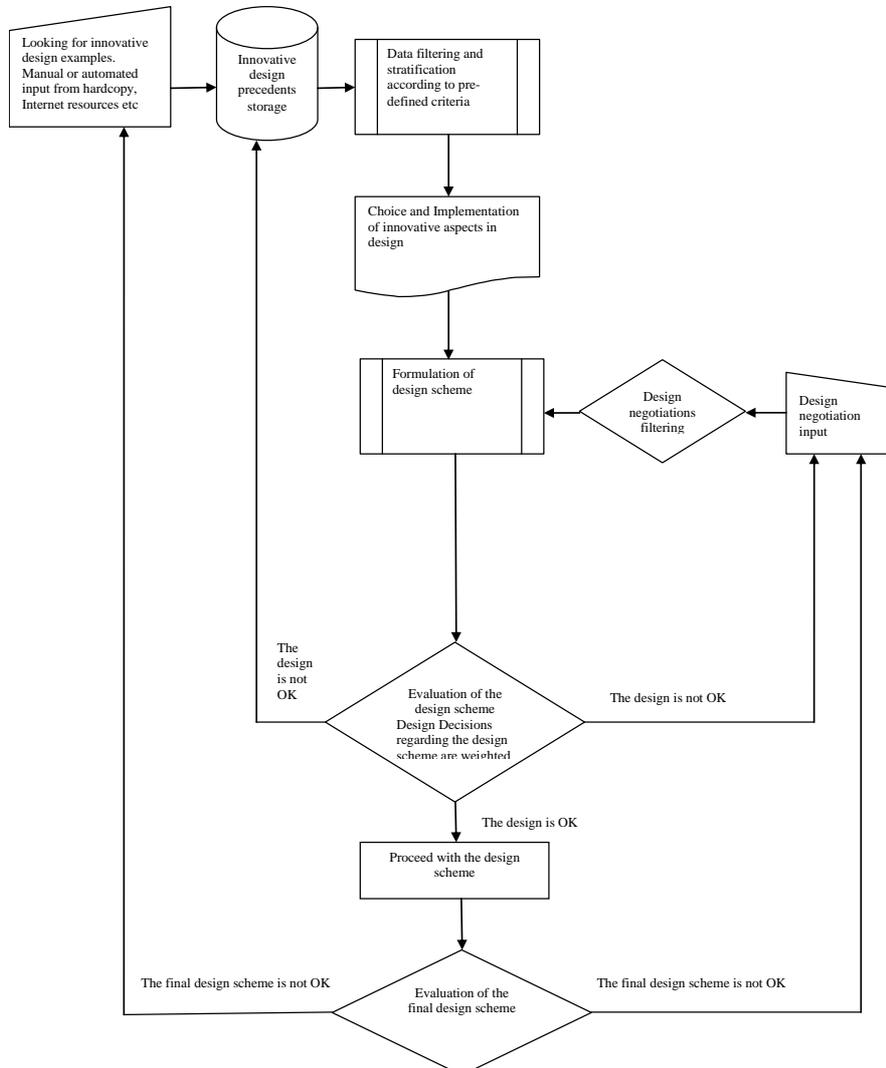


Figure 1: A flow chart that shows the components of knowledge based system that should be incorporated in CAAD systems to support the production of innovative design projects

## 6. Conclusion

The study has outlined the possible initiation and hindrances to innovation in the design studio. It also outlines a proposed CAAD prototype that would help to initiate student's communications and knowledge. The future research should explore the possible automation of the design process/ decision making process to initiate innovation. However, this CAAD prototype would not be capable to resolve all the troubled social issues in

regards to the relationship of the student with the instructor. This needs further research that looks into the causes of this troubled relationship and find possible mechanisms to sort it out.

### Acknowledgment

The author would like to thank the UD third, fourth and fifth year students and tutors who have helped the author throughout the field survey.

### References

- AMABILE, T. M. 1998. How to kill creativity. *Harvard Business Review*. no. 5 (September-October 1998): 76-87.
- ASANOWICZ ALEKSANDER 2008, How to Find an Idea? - *Computer Aided Creativity. 26th eCAADe Conference Proceedings*, [ISBN 978-0-9541183-7-2] Antwerpen, Belgium 17-20 September 2008, pp. 735-742.
- BOLAND RICHARD J., LYYTINEN J R., KALLE, YOO YOUNGJIN. 2007. Wakes of Innovation in Project Networks: The Case of Digital 3-D Representations in Architecture, Engineering, and Construction, In *INFORMS 2007*, July/August 2007 vol. 18 no. 4 631-647.
- COMPANY PEDRO, CONTERO MANUEL, VARLEY PETER, ALEIXOS NURIA, NAYA FERRAN, 2009, Computer-aided sketching as a tool to promote innovation in the new product development process, I. *Avda. Sos Baynat, s/n, E12071 – Castello'n, Spain, Computers in Industry* 60 (2009) 592–603.
- EDMONDS, E., CANDY, L. & COX, G., EISENSTEAIN, J., FISCHER, G., HUGHES, B. & HEWETT, T. Panel: Individual and versus Social Creativity. *Proc. Creativity and Cognition* 1999, 36-41.
- ELKÆR TIM NØHR, Using Computers to Aid Creativity in the Early Stages of Design – or Not! Rehabilitating the 2D/3D Physical Representation in Computer-Aided-Ideation *27TH ECAADE Conference / September 16-19, 2009 / Istanbul – Turkey*, pp. 761-768
- FISCHER, G. Designing Social Networks in Support of Social Creativity. *Proc. ECSCW 2003*, Klüver, Netherlands.
- GENNARI, J. H., REDDY, M. Participatory Design and an Eligibility Screen Tool. *Proceedings of the AMIA Annual Fall Symposium*, (Los Angeles, 2000), pp 290-294.
- GERO, J. S., & MAHER, M. L. 1993. Introduction. In J.S. Gero & M. L. (Eds) *Modeling Creativity and Knowledge-based Creative Design*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- GRAPHISOFT, 2003. *The Graphisoft Virtual Building: Bridging the Building Information Model from Concept into Reality*. Graphisoft Whitepaper.
- IORDANOVA IVANKA, TIDAFI TEMY, GUITÉ, GIOVANNI DE PAOLI MANON, LACHAPPELLE JACQUES. *Parametric methods of exploration and creativity during architectural design. A case study in the design studio*, CAD Research Group, Université de Montréal, cf 2009.
- KAN, W.T., GERO JEFF. 2008. Do Computer-mediated Tools Affect Team Design Creativity? in Nakapan et al. (eds) *CAADRIA08*, Chiang Mai, pp. 263-270.
- KAHVECIOĞLU NURBIN PAKER. 2007. Architectural design studio organization and creativity. *ITU A/Z VOL: 4, NO: 2*, pp 6-26, 2007-2.
- KVAN, T. AND GAO, S. 2005. *Examining learning in multiple settings: using a linkograph to examine design learning*, in B. Martens and A. Brown (editors.), *Learning from the Past - A Foundation for the Future*, Springer, Dordrecht, 187-196.

- LAWSON B. 2003. Schemata, Gambits and Precedent: Some Factors in Design Expertise. *Design Thinking Research Symposium 6* hosted by Creativity and Cognition Studios, University of Technology, Sydney, Australia, 17-19 November 2003, pp.37-50.  
[http://www.creativityandcognition.com/cc\\_conferences/cc03Design/papers/13LawsonDTRS6.pdf](http://www.creativityandcognition.com/cc_conferences/cc03Design/papers/13LawsonDTRS6.pdf)
- LAWSON B. 2006. *How Designers Think - The Design Process Demystified*, 4th edition, Architectural Press, Oxford.
- MAMYKINA, L., CANDY, L. & EDMONDS, E., Collaborative Creativity, in *Communications of the ACM*, 2002, pp 96-99.
- MORSE, JANICE M. (ed.). 1991. *Qualitative health research*. Newbury Park, Calif.: Sage
- MARKUS T. A. 1969. *The role of building performance measurement and appraisal in design method*, in G. Broadbent and A. Ward (eds.) *Design Methods in Architecture*, Lund Humphries, London.
- MARKUS T. A. 1969. *Design and research*, Conrad. Vol I no 2, July 1969.
- MAVER, T. W. 1970. *Appraisal in the building design process*, in G. T. Moore (ed) *Emerging Methods in Environmental Design and Planning*, M.I.T. Press, Cambridge, Mass.
- MUMFORD, M. D. 2003. Where have we been, where are we going? Taking stock in creativity research. *Creativity Research Journal*, 15, pp 107-120.
- PARKINSON MARK, ROBERTSON ALASTAIR 1999, *Securing Innovation and Creativity in Design Education*, HEQE quality and employability. [online] Available at: <http://www.markparkinson.co.uk/designeducation.pdf>
- REFFAT, R. (2006) Computing in Architectural Design: Reflections and an Approach to New Generations of CAAD, *Journal of Information Technology in Construction*, Vol. 11: 655-668. [online] Available at: <http://www.itcon.org/2006/45>
- ROSENMAN, M. A., GERO, J. S. AND OXMAN, R. E. 1992. What's in a case: the use of case bases, knowledge bases and databases in design, in G. N. Schmitt (ed.), *CAAD Futures '91*, Viewig, Wiesbaden, Germany, pp.285-300.
- SHNEIDERMAN, B., *Creating Creativity: User Interfaces for supporting innovation*. *ACM Trans. on Computer-Human Interaction*. 7 1 (2000) 114-138.
- STERNBERG, R. J., & LUBART, T. I. 1991. *Creating creative minds*. Phi Delta Kappan, 72(8), pp 608-614.
- SOSA RICARDO AND GERO S JHON, GERO J S AND BRAZIER FMT (EDS), 2002, *Agents in Design 2002, Computational Models of Creative Situations*. <http://cumincades.scix.net/data/works/att/9ec0.content.pdf>
- SULLIVAN, CERI AND GRAEME HARPER, ED., *The Creative Environment: Authors at Work* (Cambridge: English Association/Boydell and Brewer, 2009)
- THE AUTHOR. 2009. *Investigation of motivations and hindrances of innovation in the design studio: tutors' survey*. Unpublished report, College of Architecture and Planning, University of Dammam.
- THE AUTHOR. 2009. Personal contact. *Informal Discussions with the design studio instructors regarding the design studios' students' performance year 2008-2010*, College of Architecture, University of Dammam.
- WARR ANDREW MARTIN .2007. *Understanding and Supporting Creativity in Design*. A PhD thesis, University of Bath, UK.