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THE RELATION BETWEEN HEALTHY SOCIAL INTERACTION IN DESIGN STUDIOS AND THE INNOVATIVE UTILIZATION OF CAAD

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GUEST EDITORS: Bhzad Sidawi and Neveen Hamza

Bhzad Sidawi, Associate professor
College of Architecture and Planning,
University of Dammam, 31451 Dammam, P O Box 2397, Kingdom of Saudi Arabia
Email: Bsiadwi@ud.edu.sa, http://www.ud.edu.sa

SUMMARY: *The literature review has suggested that architects look for tools that would support them in their attempt to produce Innovative projects. CAAD systems help the architect in formulating and developing design ideas. Research studies have concentrated on the usability and shortages of these systems, the users' attitude, knowledge and their acceptance of these systems. On the other hand, the literature review emphasized that certain negotiation and collaboration activities are crucial to initiate creativity and produce innovative design products. However, few studies have investigated the relation between the social settings of the design studio and the utilization of CAAD systems. This research argues that certain design studio's settings would affect the innovative use of CAAD systems. In 2012, students at College of Architecture, University of Dammam were surveyed to find out how the healthy design studio's settings would support the utilization of CAAD systems in producing innovative design products and vice versa. The survey results showed that innovative and open minded students, who undertake certain design and communication tasks, found that CAAD systems are more useful in producing innovative projects than other students. The study made recommendations on how to define and set healthy social interaction conditions in the design studio so this would initiate innovative behaviour while using CAAD system throughout the design process.*

KEYWORDS: *innovation, social interaction, CAAD, design product*

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1. INTRODUCTION

The literature review has highlighted a number of problematic issues regarding the social interaction in the design studio and its' negative effects on innovation. These include the student's knowledge; attitude and design skills, tutor's support, communications between tutors and students, and type of design activities that students undertake to produce innovative projects. A number of solutions have been suggested by researchers to improve the social interaction and provide democratic, flexible, and collaborative environment. Such characteristics of a healthy social environment would initiate students' creativity. On the other hand, CAAD systems are used since 1960's. These systems are under continuous development and numerous amount of literature has pointed out to the help and support that these systems would provide designers at all stages of design process. Researchers argued that CAAD systems have the potential to improve the design skills of designers. However, there is a still a debate on how far these systems would actually help architects in performing design jobs, support design activities and innovative thinking. The literature has highlighted possible hindrances to the utilization of these systems by architects. These include the user's knowledge and attitude, and the capabilities of these systems. Few studies however, have linked the social settings of a design studio with the innovative utilization of CAAD systems in terms how these systems would help architects in developing innovative behaviour and producing innovative design products. This paper inspects possible links between the design studio's settings and the use of CAAD and how it would impact the production of innovative design outcome.

2. RESEARCH BACKGROUND

2.1. Social interaction problems in the design studio and its' impact on innovation

Gero and Maher (1993) argued that groundbreaking designs are those which possess innovative and creative qualities and provide solutions that were previously unknown (innovative design) or subsequently produce entirely new products (creative design). Sidawi (2013) suggested that innovative design product is the new product that possesses innovative architectural qualities and provides groundbreaking, innovative and inspiring architectural solutions that were previously unknown.

Innovative students can be defined as those open-minded, frequent communicators, 'think outside of the box', have a flexible attitude and negotiate design ideas. This would help them to find new design variables as the expert designers do, and this subsequently produces entirely innovative products (Sidawi 2013).

Previous researchers such as Lawson (1979), Seidel (1994), Salama (1995), Sachs (1999) Davis, Kogan & Soliman (1999), AIAS (2003), Salama (2005), Coffield et al. (2004), Ostwald and Williams (2008a& 2008b) Salama (2009), Williams et al. (2010) have examined the design education from various points of view. The research findings complemented each other, but sometimes contradicted each other (e.g. Gero vs Lawson, Casakin vs Schon). This is because the each research study was based on one of the learning theories such as Bloom, Anderson et al., Fink etc. theories. Consequently, a close examination of the reviewed literature from the creativity perspective showed in many cases, that students were able to produce new architectural solutions but not innovative ones. It showed that the aim of various architectural pedagogies and architectural programmes is to produce new design solutions but not necessarily innovative solutions (Sidawi 2013).

Also, there is no clear definition of the creativity scope for architectural projects, nor how to implement creativity dimensions into the architectural design curriculum and pedagogy (Sidawi 2013). There is an emphasis on frequent and democratic social communications but it is not clear how to communicate, from whom useful information can be obtained, rules of communications and how to filter and incorporate the outcome of the communications in the design scheme to enable the production of innovative projects (Sidawi 2013).

Previous research suggested that the design studio's culture restricts the intelligent students from using their knowledge and this would have a negative impact on their design communications and progress. The literature motivated students to explore design from unorthodox perspectives and the inspection of possible solutions. This would help in producing new design products but not necessarily innovative products (Sidawi 2013). It was

highlighted main problematic areas that explain why the interaction between the student and instructor is not functioning and design negotiations do not reach a fruitful innovative result, despite the frequent communications between them (ibid). This would affect negatively the student's ability to produce innovative design products. These areas are (see table 1):

a. the design studio culture: this includes: i) the dominance of the instructor's opinion and design approach's style (Seidel 1994 and Salama 1995), ii) autocracy at the design studio and College levels (Davis, Kogan and Soliman 1999, Salama 2005: Schon 1980s), iii) lack of support from other departments' instructors and students, iv) the student's poor levels of trust in the instructor's design ability; and v) some intimidating practices; and

b. the pedagogy of architectural design: this comprises: i) lack of tutor's support, whether in the type of support, the timing or the clarity (Seidel 1994), ii) performance and clear ways of instruction (ibid); iii) commitment and knowledge (ibid); and iv) flexible thinking and understanding of creativity (Williams et al., 2010).

Table 1. Existing social interaction problems that hinder innovation in the design studio

Design studio's criteria		Existing hindrances
a. The design studio's pedagogy and approach to design		There are differences in the pedagogical language and theories used in higher education (Coffield et al., 2004)
		The architectural design pedagogy focuses more on form issues, while oversimplifying programmatic and contextual contexts within which buildings are created (Salama, 2005). Thus architectural design pedagogy focus can be considered as incorrect, and suffers from programmatic and contextual context problems (Salama, 2005)
		Socio-cultural diversity of most architectural projects possesses many hidden dimensions. These hidden dimensions are usually not covered within the realm of course contents (Dutton, 1991)
b. The teaching and communication style and communicators' qualities	*b.1 teaching style & comm..*	Design tutors have a lack of: a. understanding of the pedagogical dimensions of creativity in architecture and design; b. appropriate strategies to understand where different levels of creativity occur and how they should be assessed; and c. appropriate models or tools to support the assessment of the creative component of design (Ostwald and Williams, 2008a; 2008b)
	b.2. Tutors' qualities	Design instructors are not clear about their studio goals or objectives and will change them from the start of the project and during the assessment process (Seidel, 1994)
		Instructors tend to consider teaching practice to be an intuitive process based on subjective view points and personal feelings (Salama, 1995)
		The teaching and judgment of design creativity inevitably rely on the instructor's subjective understanding of creativity thus students may find themselves confused as to the requirements of their creative tasks (Williams et al., 2010)
		Over-defined learning and assessment outcomes stifle the students' opportunities to be creative and teachers fail to recognize their creative efforts (Ostwald and Williams, 2008a)
	b.3. Design students' qualities	Students are passive learners (Salama, 2009)
		The design studio assumes the mastery of the instructor thus the student has to believe in the power of the instructor (Salama, 2005)
c. Design studio's culture		Teachers may tend to be autocratic, repressive, and do little to encourage individuality and creativity (Davis, Kogan & Soliman, 1999)
		Current studio culture rewards students with the best-looking projects (AIAS, 2003)

2.1.1. Possible solutions to improve the social interaction

To improve the design studio environment and help students to produce innovative projects, it is suggested that the design studio environment should be healthy in respect to the communications, teaching style, design studio's culture; and students and tutors' qualities. For instance, instructors should be sensitive to the indications of students' needs so they provide them with their support at the right time (Sidawi 2012a&b). Clear instructions and objectives should be set at the start of the course. These should be linked to the creativity dimensions. Also, tutors should set a clear roadmap on how to apply it during the design project, and thus discuss it with students to reach a common understanding of the application of the creativity dimensions in the design project (ibid). Shared understanding regarding creativity is also required with the jurors. Students should have a project diary and record their design thoughts and information they got from various sources. Students should be taught how to look for innovative architecture solutions, explore the innovative aspects of each case study, experiment with possible links between innovative design aspects/solutions and each dimension of the design problem, in line with expert designers' usual practice. Also, they should experiment with possible links with the ideas that they have obtained from the design negotiations. Instructors should not impose their own ideas on students but introduce them to students and encourage students to explore how the potential solutions can be integrated with the students' design ideas. Instructors' communications and interactive skills and their ability to perceive innovative abilities of students are essential (ibid). Keeping a record of the design negotiations and innovative design precedents would be useful as it may help the student to track the progress of the design, explore new links between design negotiations at the various stages of design, and the design problem. Students should frequently discuss design ideas with colleagues and instructors as this would substantially improve their design abilities. Students should be open-minded and 'think outside of the box', have a flexible attitude and negotiate design ideas (ibid). This would help them to find new design variables as the expert designers do, and this subsequently produces entirely new products. However, frequent communications and learning from experts would not achieve their objectives without providing solid foundations and changing the way of teaching instruction and methodology. The teaching instruction in the design studio and assessment of design projects should not focus on form issues and following solution-based approach to find new solutions for design problems. The focus should be on adopting innovative-based design approach and how to find innovative solutions rather than merely new solutions to the design problem (ibid).

2.2. The social interaction relation with the utilization of CAAD

The amount of support that CAAD systems would provide to the architect, the role it plays in initiating his/ her innovative abilities and the successful integration of CAAD with design education would be impeded by a number of factors. These include: students' attitude toward the technology (Pektas and Erkip 2006, Al-khaldi and Al-jabri 1998), differences between the attitude and approach presented by males and females (Winn and Banks 2012, AAUW, 2000, Siann, 1997, Clegg and Trayhurn, 1999). Researchers have researched possible links Between Computer Aided Design (CAD) and creativity (Musta'amal, Norman& Hodgson 2009). These researchers encouraged students to develop innovative behaviour while using CAD. They pointed out that the user should anticipate the use of CAD throughout designing and this would display more innovative behaviour. Tweed (2001) investigated the relation between the social and physical background of the practice and the utilization of CAAD systems. He reported that cognitive approaches failed to address the innovative and improvisational character of systems' use in 'practical situations of choice' because they focused on the knowledge users have of a system rather than on how that knowledge is used awithin the situated accomplishment of a range of social actions and activities (ibid). He emphasized on the importance of the socio-cultural situatedness of designers, the physicality of the designers' workplaces, bodily placement and the kinaesthetic sense that is involved in designing areas.

2.3. CAAD systems, architectural design and innovation

The advent of computation and information technology had profoundly altered architectural thinking (Sidawi and Hamza 2012). Design software and numerical fabrication have recast the role of form giving and shaping environments in architecture and opened up unprecedented opportunities of investigation and links with other scientific domains such as biomimcry, parametric design and modelling of urban and building environments (ibid). Researchers investigated the use of CAAD tools by architects and how it would support design activities and help in producing innovative products. CAAD systems assist the architect in formulating and developing

design ideas (Rosenman, Gero and Oxman 1992). During each of the design stages, the architect use these systems to model, visualize, communicate and present design ideas, and negotiate each component of the design product (Boland 2007, Kan& Gero 2008, Elkær 2009, Iordanova et al 2009 and Company 2009). These researchers argued that CAAD systems have the potentiality to improve the design skills of designers (ibid).

Van Dijk (2005) anticipated that the success of integrating computer systems with architectural education depends on the way that computers are integrated with architectural design and theory. This could reflect the students' motivation to use computers in everyday life as a social phenomenon rather than a learning tool, and would indirectly brought new skills to the design studio context (Salman, Laing & Conniff, 2008). These researchers indicated that the combination of physical and digital media and design methods added insights and better means to (re) consider and (re) fine a design. This integration might increase the student's experience of inquiry, discovery and representation and this leads to creativity (ibid).

Researchers investigated possible ways of developing CAAD systems to support design activities. They suggested the 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 focused on design cases, analysis, problem/ solutions, constraints etc. (Rosenman, Gero and Oxman, 1992). 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).

Tasli and Sagun (2002) suggested that whole life cycles of buildings should be dynamically simulated in visualised virtual environments to evaluate the future performance of prospective designs. This can be through the evaluation of user-building interaction and visualisation of environmental factors. 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). Timothy (2012) looked at enabling the implementation of parametric modelling and use of digital fabrication in the production and making of architecture. This would help the users to understand the CAD technique or parameters for modelling, translate for CAM production and deal with real world constraints of materials, time and tectonics.

Von Mammen and Taron (2012) implemented multi-agent system that models complex biological systems. This may help users to explore the connection between architecture and natural environment and envisioning biomimetic code as Architecture, Architecture as nature, and nature as codified milieu. Simone and Antonio (2012) presented the construction of a general representation template of user-actor (i.e. agent), easy to implement and flexible enough to structure the large amount of data affecting human behaviour and interaction with the built environment. They push the debate on agent based simulation of buildings use to predict and evaluate future building responses to future user intentions. Sidawi and Hamza (2012) suggested methods of incorporating intelligent and open sourced digital repositories to enhance the incorporation of precedents knowledge. This would help users to gain a critical mass of knowledge that would underpin informed design decisions and assess how far the present design scheme is innovative.

Ramilo and Bin Embi (2014) found that Digital technologies are proven to improve productivity and design quality but they are not used for digital innovation in small practices. Substantial organizational and technological barriers inhibit the effective adoption of these technologies, thus practices should consider how to overcome these barriers to enable digital innovations in the practice.

3. THE RESEARCH OBJECTIVES AND METHODOLOGY

The literature review highlighted the importance of healthy social settings in supporting the innovative utilization of CAAD. It proposed links between the utilization of CAAD with the innovative behaviour on one hand, and on the other hand, with physical and social interaction parameters. It however, did not point out exactly which and how social interaction parameters would support the innovative utilization of CAAD. The present investigation was based on a pilot study on tutors and a survey on students and these were carried out in 2009. This research argues that healthy social interaction is essential to initiate innovation thus the innovative utilization of CAAD. It investigates the possible links between social settings at University of Dammam (UD),

College of Architecture, and the perceived use of CAAD as a tool that helps producing innovative projects. The objectives of the research were set as the following:

- to find out how CAAD systems are helpful in producing innovative projects;
- to inspect social settings of the design studios; and
- to explore possible links between the utilization of CAAD and the present design studio's social settings.

A survey has been conducted in 2012 at the college of Architecture, UD. The aim of the survey is to find out the level of general agreement on the raised issues. The sample was chosen from the third to fifth year's design studio students. The total number of students in these studios is 103 students. It should be mentioned that fifth year students are more expertise in using CAAD (i.e. AutoCAD, SketchUp, Autodesk 3ds Max and Revit) than third year students. There are no female students at the College of Architecture, so the questionnaire survey was carried out on the male students from third to fifth year. Forty eight replied and handed back, which constitutes 46% of the total number of third to fifth year students from the Architectural department.

Subsequently, students were invited for an interview and seven students from the third, fourth and fifth year accepted the invitation. Students were interviewed using unstructured interviews. The interview data were analysed by classifying it into categories and making comparisons using cross-referencing (i.e. similarities and non similarities) which allow interpretation and judgment.

It should be mentioned that at the start of each semester, students are usually given a brief of the design problem and they visit the project site. They are asked to analyse couple case studies, the site parameters and use the analysis outcome in developing their projects. They are given lectures on how to analyse case studies of existing design projects, and related subjects to the design process such as sustainability and urban design, as applicable, during the semester. They usually work in groups at the start of the semester (i.e. during the site analysis and case studies stages) thus each student develops his design ideas with the help of his tutor.

4. DISCUSSION OF THE SURVEY RESULTS

4.1. The direct results

Students said that the most helpful CAAD tools in producing innovative projects are: advanced modelling systems, advanced rendering programs, walkthroughs generated by the computer, standalone virtual reality, and computer animation. The least useful tools are: web-based virtual reality, computer simulation of building behaviour, immersive virtual reality, and smart white board. This can be referred to the fact that students did not experience the use of these tools whereas the earlier mentioned tools have been tested and used (table 2). In respect to social settings of the design studio, students highlighted negative and positive aspects.

Table 2. How CAAD systems are helpful in producing innovative projects (scale: 1= not helpful at all to 5 very helpful, sample size is 48).

Type of CAAD tool	Mean	Std. Deviation
Advanced modelling systems	4.4565	0.93587
Advanced rendering programs	4.1522	1.01033
Walkthroughs generated by the computer	3.9111	1.1446
Standalone virtual reality	3.9091	1.19725
Computer animation	3.8864	1.29787
Web-based virtual reality	3.6667	0.95424
Computer simulation of building behavior e.g. thermal, environmental, users' movement	3.6512	1.28885
Immersive Virtual reality	3.6047	1.198
Smart White board that is used for presentation and discussions	3.2381	1.57433

They said that their tutors frequently encourage them to make many attempts to develop the design solution (table 2). Tutors frequently work on developing innovative ideas of students, and they give them the complete freedom to do innovative design.

Students frequently generate many sketches before making up their mind, capture innovative ideas from other departments' tutors, and having interactive and useful dialogue with tutors on how to reach to an innovative design solution. They said that they frequently use and integrate different tools to initiate creativity and creativity (e.g. brainstorming, group work, etc.) meanwhile they mentioned that the tutor's ideas have the greatest weight in the design process which may negatively impact innovation (table 3).

The interviews revealed that students were unhappy about the tutors' attempts to impose their design ideas and see this style of teaching as a threat to their innovative thinking. Students said that most support that they got from their tutors is regarding to the following cumbersome situations (table 3): low level of knowledge regarding one of the design aspects, misunderstanding of some project requirements and the attempt to change the whole design solution during the design process. However, the level of support for the rest of cumbersome situations seems to be weak and infrequent (see table 4).

Table 3. The frequency of activities and communications that happen in the design studio during the term time as seen by respondents (scale: 0= does not happen, 4 = always happens, sample size is 48)

Design studio's criteria	Type of communications and activities within the design studio	Mean value
a. The design studio's pedagogy and approach to design	My tutors encourage me to make many attempts to develop the design solution	3.356
	My tutors encourage me to follow various approaches to reach an innovative solution	3.174
b. The communications style and communicators qualities		
b.1. Tutors' qualities	My tutors work on developing my innovative ideas	3.383
	My tutors give me the complete freedom to do innovative design	3.362
	I am praised and rewarded when I present an innovative design solution	3.298
	Strategies to motivate and initiate creativity are applied in the design studio	3.255
	The tutors successfully handle conflict through constructive dialogue	3.13
b.2. Design students' qualities	The generation of many sketches before making up one's mind while working on a design problem	3.809
	Capturing innovative ideas from other departments' tutors.	2.689
	Having interactive and useful dialogue with tutors on how to reach to an innovative design solution	3.447
	Capturing innovative ideas from colleagues from the same design studio	3.468
	Not taking many risks because of the fear of failure	3.375
	Seeking students and staff from different departments to help in solving specific design problems	3.375
	Capturing innovative ideas of colleagues of a higher academic level from other departments	3.267
	Capturing innovative ideas of the same academic year colleagues from different departments	3.178
c. Design studio's culture	The tutor's ideas have the greatest weight in the design process	3.867
	We always use and integrate different tools to initiate creativity and creativity (e.g. brainstorming, group work, etc.)	3.239
	The design studio environment is governed with an open, participative culture	3.17
	The design studio environment is governed with a forgiving culture, patient with failure and trustful	2.913

Table 4. The frequency of support that student gets from the instructor regarding the cumbersome situations that he experiences during the design project period (scale: 1= rarely to 5= very often, sample size is 48)

Type of cumbersome situation during the design project period	Mean value
Low level of knowledge regarding one of the design aspects	3.568
Misunderstanding of some project requirements	3.289
The attempt to change the whole design solution during the design process	3.279
Stuckness	3.222
The attempt to change of the approach to the design solution during design process	3.222
Confusion over the nature and context of the design process	3.156
Misapplication of one of the design requirements	3.156
Uncertainty of how to design one of the project aspects	3.091
Hesitation to take the next step	3.046
Confusion over the context of the prospected design outcome/result	3.044
following a wrong route during the design process	3
Misjudgment about the resulted design of one of project aspects	2.977
Lack of the design skills required to design the project	2.822

4.2. The Anova results

The analysis of data revealed links between the student's design activities, communications, and the tutor support, with the usefulness of CAAD systems. The innovative utilization of various CAAD systems, as perceived by students, was associated with the increasing frequency of the following activities (table 5):

- a) the design activities such as the generation of many sketches when they work on a design problem;
- b) communications with tutors and students such as: seeking students and staff from different departments to help in solving specific problems, and discussions with their colleagues from a higher year;
- c) tutor's support to innovative design activities: this is concerning the tutor's development of innovative ideas of the student; and
- d) tutor's support regarding the following cumbersome situations: lack of the design skills required to design the project, misunderstanding of some project requirements and stuckness.

Table 5. ANOVA results showing the significant relations between social settings variables and CAAD utilization variables (level of significance <0.05 and the level of confidence is 95%)

Variable 1	Variable 2	F	Sig.
Advanced modelling systems	When I work on a problem, I generate many sketches before making up my mind	3.822	0.03
Advanced rendering programs	I seek students and staff from different departments to help in solving specific problems	3.348	0.045
	When I work on a problem, I generate many sketches before making up my mind	2.768	0.04
Walkthroughs generated by the computer	When I work on a problem, I generate many sketches before making up my mind	3.267	0.021
	My instructors work on developing my innovative ideas	3.279	0.021
	Discussions with your colleagues from a higher year	6.154	0.001
Standalone virtual reality	Discussions with your colleagues from a higher year	4.801	0.003
Computer animation	Discussions with your colleagues from a higher year	4.651	0.015
	When I work on a problem, I generate many sketches before making up my mind	2.742	0.042

5. CONCLUSION

The previous research has indicated a number of parameters of healthy environment in design studios. It highlighted that tutors and students should be flexible, open-minded, and should have Shared understanding of how to apply creativity dimensions in the design project. Students should look for innovative precedents and experiment how to link it to the design scheme. The literature review demonstrated how healthy social settings would affect positively the CAAD use, thus CAAD would support students in their attempts to develop innovative design solutions. This study demonstrated to a certain extent the possible links between the social settings of a design studio and the innovative utilization of CAAD as perceived by students. It indicated the importance of healthy social interaction which would initiate innovation thus help students to undertake innovation design activities. These design activities should be supported by healthy communications, and continuous and timing support from their tutors and colleagues. This would help students using CAAD systems in an innovative way providing that the use is conjugated with innovative design activities and the implementation of innovative scope and objectives for the design studio's curriculum. This however, would not succeed without developing customized intelligent CAAD systems that would support innovative and intelligent utilization of these systems.

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