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Current Discussions on Digital Sketching in the Early Stages of Architectural Design in Education

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Abstract

In the architectural design, designers are focused on the early stages of the design process or conceptual design. The ultimate goal of this stage is to find a solution for an existing problem, investigate design space, or explore an idea. This stage conventionally begins with sketches and diagrams to explore ideas and solutions; the ambiguity and vagueness of conventional freehand sketching can be a source of creativity.

Nowadays, with the advances in digital technology, there are attempts to integrate digital tools into the conceptual design in order to construct a digital design medium in the architectural education. Recent developments in CAAD software shows a shift in focus toward conceptual design interface; but these tools have not developed and still fail to offer an appropriate design environment for sketching; So application of digital tools in the early stages of design, has created problems and challenges especially regarding creativity. The problem is that why digital sketching could not yet replace the conventional freehand sketching. Therefore, this research focuses on the early stages of the design process and aims to investigate the current situation of digital sketching and its related discussions and challenges in architectural design education, also, study the current sketching tools in the architectural schools and tendency of instructors and their students to use digital sketching in real world. This research has a qualitative approach and a survey has conducted via an online questionnaire. Findings show that, there are attempts to study and propose interfaces and programs to enhance digital systems or new ways of working with them in order to support creativity and sketching. Also, findings indicate that the professors yet doubt over digital tools, but there is a tendency to use these tools among educators and their students if these tools can meet educational demands.

Keywords: *Conceptual design, Digital sketching, Creativity, Pen based sketching.*

1. INTRODUCTION

With the revolution of computer technology, more software are developed, which have been utilized in many ways including drafting, design, simulation, analysis, and manufacturing to visualize in three dimensions and to simulate aspects of performance and the coordination and control of production information [1-2]. Nowadays, the digital technology began to affect the thought process of the designer; therefore, digital technologies are now enabling a move from drafting and visualisation to the generation and optimisation of design [3]; but existing conventional digital software does not yet support the early conceptual design phase thoroughly [4].

When computers are not commonly used in conceptual design phase, many architects use pen and paper and model making to express their designs and presentations; while in architecture schools, many, if not most, architectural students start their earliest design experiences quite naturally by using the computer [5]. However, today due to the low willingness of professors to use this technology, programs fully based on digital technology are not available in training. Hence, the research questions can be as below:

1) Why the digital sketching are not commonly used in architectural design studios?
2) How digital sketching can replace the conventional freehand sketching?
3) What is the situation of digital sketching in architectural schools?

The purpose of this paper is study the status of digital sketching in early design stages and their current challenges in the educational field especially regarding creativity and why computers are not yet commonly used in the early phases of architectural design. Also by studying and investigating current digital sketching tools attempts to find out recommendations for developing digital interface to support sketch and creative design

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process. Therefore, the study consists of three main sections: the first section outlines current discussions about the digital technology in the early stages of design and especially regarding creativity; the second section describes and reviews the digital sketching tools especially pen based systems and their possibilities, and in the third section a pilot study is conducted to show the current situation of digital sketching in architectural schools in real world.

1.1. Literature background

Thinking in sketching digitization started decades ago with SketchPad presented by Sutherland. From this date, a body of work was presented to enhance this direction of research [6]. According to background of the research issue, the literature can be consisted several study areas from different points of view.

Some researches (e.g Rauhala [7], Dokonal & Knight [8], Verstijnen et al [9]) review and explore the role that computers can play in the early design stages and sketching process. Some studies such as Lawson [1], Musta'amala et al [2], Hamre [3], Verstijnen et al [9], Haapasalo [10] also focus on searching and discovery of sketching behaviours and opportunities to support creative designing by using digital technology.

Other research (such as Hamre [3], Gross & Do [11], Lim [12], Vries & Achten [13]) describe current digital sketching programs -sketch-based and pen-based interface- to explore essential elements of sketching and focusing on their support for problem solving. Some studies such as Gharib [6], Pranovich [14], Gharib [15], Aliakseyeu [16], aim to develop a sketching environment to feel as natural as sketching on paper to improve and enhance idea generation process.

2. CURRENT DISCUSSIONS ON DIGITAL SKETCHING IN ARCHITECTURE EDUCATION

According to available literature, the research is studied and classified as following sections that attempts to discuss on using digital sketching in the early stages of architectural design in education field and on using of digital sketching regarding creativity.

2.1. Digital sketching in the conceptual design

While digital media is spreading rapidly in design education, the value of using traditional or digital media and tools has been the subject of debate among design educators [17]. In recent years, when reviewing design education, educators have been confronted with the polemics of hand versus computer, or traditional versus digital media. It seems that, the conservatism and anxiety of instructors toward using digital tools in teaching is natural because, the senior instructors have not 'grown up' with computers which makes them have unfavorable attitudes toward computers.

Dorta [18] states, "The problem here is that in the architectural schools, ideation is still done as it has been since the Renaissance, by traditional analog manual tools, like sketches and physical models, without real support from current digital tools". In contrast, Lawson notes, "mounting evidence that CAD infiltration in design education is resulting in good design skills being supplanted by good computer skills"; he argues that, "it has always been possible to find excellent presentation combined with poor design. However, before the advent of CAD, it seldom happened in practice" [1].

Daru [19] posed four criteria for assessing computer based sketching as: "1) *Is computer sketching didactically correct*? The ultimate goal is to learn designing rather than producing the nice or pleasing pictures; 2) *is it useful*? The answer is positive if it gives additional possibilities for the idea production in designing or if it shortens the learning time of design sketching; 3) *is it sufficient?* Can hand sketching he replaced by computer sketching entirely? 4) *is it harmful?* Are such exercises detrimental to traditional sketching experience?" Answer to each of them will open new contexts to discussion; each of them can be a research questions that leads to solve a part of digital sketching' problems in educational field.

Recent developments in CAAD software shows a shift in focus towards conceptual design interfaces**;** but, according to some researchers, these tools have not developed and still fails to offer an appropriate design-oriented environment for design sketching [5, 20], thus, designers abstained from using CAD systems to sketch and still do sketching using pencil and paper [6, 15]. As discussed by Bilda & Demirkan [17], the design apprentice software was not suitable for the conceptual design process, as it lacked support for designers' habitual activities such as doodling and sketching activities.

It seems that, the lack of using computers in the early stage of design process comes back to its inefficiency in enhancing creativity of students as an ultimate goal of design training.

2.2. Digital sketching and creativity

As previously noted, current digital media systems apply well in the final and routine phases of design, but the applicability in the early conceptual phases is poor. Additional to previous statements, the most researchers believe that the use of computers in the early stages of design may impede the creative behaviors. According to them if a designer starts to use CAAD from the beginning it can limit his creativity and can encourage poor design.

Lawson [1] states that, "the problem is that if the computer uses the wrong metaphor for describing design features, it can inhibit the creative integration that design requires in order to be what Hertzberger calls 'real' as opposed to 'fake' creativity". Verstijnen et al [9] have examined 'combining' and 'restructuring' in sketches as a creative process, and have evaluated 3Dimentional CAD programs on these issues. They concluded that they are not helpful as tools for idea generation sketching in the early creative phases of the design process.

Rauhala [7] believes "it seems impossible to use computers as a creative adviser or as a generator of totally

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new design solutions". Dokonal & Knight [8] claims 'that is not true anymore', and say that modern CAAD software is at least an additional possibility to start a design with clearly new benefits and still some disadvantages. According to Bilda [4] digital systems lack the cognitive aspects of architectural design, thus, trying to use computers creatively seems to be generally impossible.

According to researchers, there are several reasons to explain why digital systems inhibit design thinking and creativity in the design process. This reasons can classify as following:

Computer-user interaction: According to researchers, the interaction between designers and computer is not sufficiently intuitive and natural, and it prevents the designers from focusing and concentrating on the creative thinking [20]. Dorta & Pérez [21] and Gharib [15] expressed that, the user interface based on commands, messages, menus, mouse, and keyboard is still hindering the creative flow in ideation and thinking process; Lawson [1] explained that, "the high resolution of CAD representations distract the designers' attention from whole to detail and limit their ability to see and interpret things in new ways". Also according to Aliakseyeu [16], "the use of a digital system does not match the development speed of thought and idea while in traditional sketching, the pen is a natural extension of the hand, so using the computer shifts the attention away from the actual design process". In these statements, the lake of appropriate interaction between designer and computer as a design medium have been explained from different point of view, that seems nowadays with the emergence of pen based systems, part of these problems can be overcome. Although the skills and abilities of computer users in using programs, is the other reason that can provide a great interaction between designer and computer as a design media.

Computer interface: Computers according to current computer-based sketching systems are often non-dense and unambiguous in representations and do not allow abstractions and uncertainty, which play an important role in the conceptual design process [21-22]. Daru [19] states that, "computers are not offering an adequate environment for design sketching". According to Dorta & Pérez [21], "Digital systems encourage working with precision and details while allowing little room for vagueness because computer interface (software and hardware), which always demands specific abstract and accurate data; and discourage the designers to modify their ideas resulting in premature fixation due to their inflexibility that limits creativity". Pranovich [14] believes that in the early stages of design computers manifest their inability: "they are inflexible, unimaginative, and tedious; and they support focuses on quantitative rather than qualitative support". According to Lawson [1], "computers are poor at recognition, interpretation and the reconciliation of conflicting demands". Indeed, the mechanical nature of digital techniques and structured CAAD environment [11] have constrained their application during the early stages of design; and Haapasalo [10] claims, that, it is very difficult to find mathematical algorithms, which can imitate or increase creativity.

These discussions show that a great part of the problem is relate to design appropriate computer interface systems to support the sketching activity and later the creativity. The interdisciplinary researches between architecture, mathematics and computer science can create proper solutions in this respect. For this reason, with advancing in new technology, there is evidence that CAAD start to be effective in conceptual design and sketching process related to creativity. Some researches have been conducted to explore it. According to Rauhala [7] "they are not helpful in creativity itself, they can be indispensable in technically validating new ideas". The analysis and findings of Musta'amal et al's [2] studies, suggest link between the emergence of creative behaviors and the use of CAAD in designing; and according to them "it might potentially encourage creativity in designing". In addition, the suggestions of different researchers indicate that, digital media have elevated the mental ability of the designer to visualize and evaluate abstract ideas as a facilitator of design ideas but is not a creator of the content. Mohd et al [23] in their study indicate that CAAD technology in the design process can help students to produce creative architectural product, stimulate creative ideas during the design process and increase the number of ideas in the synthesis activity, because "it causes designers to re-think previous ideas and to improve the quality of their designs" [23]. The computer programs according to its nature and algorithm systems utilize and get help of different drawing orders; so can provide a context to manipulate and play with the old drawings, create new drawings and reach to different solutions. This reinterpretation of ideas can lead to creative thinking process. Haapasalo [10] believes that, "with the computer, artists, designers may easily play with hundreds of solutions or variations. Thereby computers may have a supportive impact on creativity". According to him, the computer can be considered as a machine to achieve a greater ability to think.

2.3. Recommendations for digital interface to support sketching

Researches which attempt to find knowledge for designing sketch based on user interface, offer recommendations for supporting digital sketching tools in conceptual design. In order to better integrate the computer tools into the conceptual design process, Gross and Do [11] suggest that, "digital support for creative design in architecture should include retrieval of visual references with similar forms. This aims to support three aspects of creativity: combining ideas from different sources, using visual metaphor and analogy, and expanding the search space to include innovative solutions". Lawson [1] states two conditions; *first*, "the computer program must offer new possibilities, rather than simply aping existing ones". *Second*, "the program must be in the hands of an artist who can be creative in the medium". One possibility in

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developing user interfaces is move in a more flexible direction and more close to the natural and traditional architectural design process, and provides benefits not available with paper, such as the ability to simulate the system to support creative design work [11, 24]. To design an interface that feels natural to sketches, the system must be able to provide ambiguities and imprecision. In this way that, the architect must be able to sketch, write, model or search for new images over the editing of existing drawings, in an easy, intuitive way in order to enable the architect to focus on the design problem and not on how to use the program [9]; so a digital sketching tool according to Do [24] "should recognize static drawing marks, such as simple geometric shapes, and their spatial relationships"; according to him**,** for building useful digital sketching tools for design, one must identify the dimensions of sketching. This includes identifying drawing components and design entities and the spatial relationships and transformations among them. The familiarity of users with digital sketching programs and their ability to benefit of possibilities that digital media provides to designing as Lawson [1] state, is a key aspect and reason that can determine the interest of users (instructors or students) to use digital sketching. This issue is explored in pilot study.

Therefore, in order to comprehensively assist designers to produce more stimuli for their designs in the conceptual stage, computer-aided conceptual design (CACD) was gradually explored and developed [12,22]; the disadvantages of the current state of CACD which mimics free-hand sketching behaviors indicate that few digital tools exist to address the early phase of the conceptual design and a dense and ambiguous representation for CACD is still difficult [22].

Summary: These discussions and researchers' opinions are summarized as shown in Table 1.

Table 1 Summary of discussions (advantages and disadvantages of digital sketching)

Disadvantages	Advantages	Recommendations
• Combining excellent presentation with poor design • Fail to offer an appropriate and adequate design environment for design sketching • Using the wrong metaphor for describing design features • Being inflexible, unambiguous • Focusing on quantitative rather than qualitative support • Being poor at recognition and interpretation • Not supporting designers' habitual activities • Not being an intuitive interaction between designers and computer • Distracting the designers' attention from whole to detail • Hindering the creative flow in ideation and thinking process • Encourage working with precision and details • Discourage designers to modify their ideas (premature fixation)	▪ Elevating the mental ability of the designer to visualize abstract ideas ▪ Increasing the number of ideas in the synthesis activity ▪ Enhancing students' desire to gain more design ideas ▪ May encourage creative behaviors ▪ Can help students in stimulating creative ideas ▪ May play with hundreds of solutions with the computer ▪ Can be consider as a machine to achieve a greater ability to think.	✓ Offering a new possibilities ✓ Ability to search new ideas by editing the existing drawings ✓ Enable the architect to focus on the design problem and not on how to use the program ✓ Should recognize drawing marks ✓ Identifying the dimensions of sketching ✓ CACD systems are based on a digital sketching environment that mimics free-hand sketching behaviors

The studies show that in the architectural schools, ideation and designing is still done by traditional manual tools, and according to current interface of sketching programs, it seems that it is yet impossible to use computers as a sketching tool to generate of new design solutions or creative thoughts in the conceptual design stages. Although with advancing in digital technology, nothing is impossible.

3. DIGITAL SKETCHING TOOLS

As previously outlined, sketching is generally associated with early, conceptual design and there are ongoing efforts to find out how computers may help in the conceptual phase of design process [4]; therefore, researchers directed into developing sketch-based interfaces for modeling (SBIM) [15, 25].

The idea of sketch-based modeling is not new. It dates back to Sutherland's sketchpad system. In this system, the user produces 2D drawing by sketching directly on a computer display device using a light pen [6, 15, 25]. In the last decade, we have seen an explosion of both sketch-based interfaces and pen-based computing devices. Each generation of sketch-based interfaces can be traced to different hardware devices that shaped their inception and evolution: the light pen, the digitizing tablet and stylus combination, later the mouse, more recently tablet PCs and PDAs and multi touch surfaces as well as pen based PC software [25]. Generally, the development of early design tools has relied heavily on sketching input and these tools mimic the traditional architectural environment, simplify interaction with the system and support various design aspects [14].

Also, Sketching support tools[1] can be divided into two classes: 2D sketching support, for example tools like

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Cocktail Napkin Fig. 1 and Autodesk SketchBook Pro; and 3D sketching support, for example tools like DDDoolz Fig. 2 [13], and SketchUp. Actually 2D sketching interfaces imitate the pen and paper features. They have disadvantage that provide digital methods for drawing, coloring, and shading which make designers concentrate on the process rather than the idea. For these reason, developing a new 2D sketching interface that uses freehand sketching in the same way of pencil and paper is essential [6].



Fig. 1 Electronic cocktail napkin environment

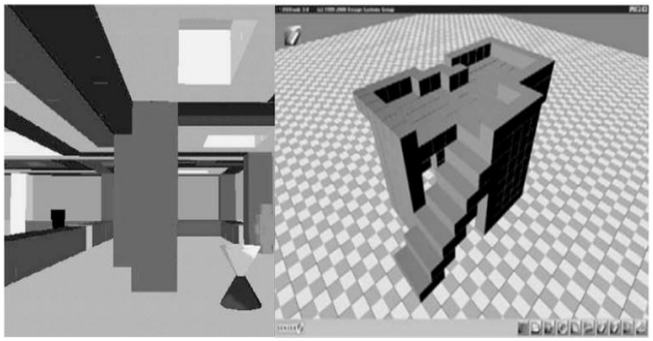


Fig. 2 3D sketchs are created using DDDoolz [13]

3.1. Pen based sketching systems

As previously cited, the most of designers are still relying on the conventional media– pen and paper. Since these mouse based computer media are incapable of supporting the functions of pen and paper during initial sketch, many researchers (like Hamre [3] and Lim, [12]) turned to the research and development of pen based systems. In 2D pen based systems, instead of using a pencil on a piece of paper, one will use a stylus on a touch screen. The only difference is the design environment. The application was implemented on a for example tablet PC with a pen input device, with a consistent pen-based interface that mimics pencil and paper sketching, but with the assistance of the computer to enhance and augment the process [12, 24, 26].

Since, the emergence of stylus driven "touch-screen" PC tablet hardware, coupled with freehand sketch software; so, the purpose of this system is to provide the CACD (Computer Aided Conceptual Design) system with conveniences and functions like fast expressions of images in designers' brains, ambiguity, resolution, gesture, and notions [12]. Certainly, the additional of this new technological tool does not threaten traditional drawing; and can help designer to think while designing in the conceptual design stage. The first tablet PC can be traced back to the 1960's; GRIDPad in 1980's and in 1990's ThinkPad tablets are introduced. In 2001, Bill Gates introduced the world to the Windows XP Tablet Edition that included a touch screen and compatibility with the desktop computer. The unveiling of the Apple iPad in early 2010, provided the world with a device that bridged the laptop computer with the smartphone providing ultimate user mobility and flexibility. Today, the digital tablet has the stylus meant to substitute the pen and screen in lieu of a piece of paper [3].

However, what is the advantage of using computers to support sketching when they merely emulate pen and paper tool?

The major added value of such tools in comparison with pen and paper is the facilitation of the transition from the early stage to more definitive stages of design [16]; also, the use of sketching using digital technology as it tends to reduce barriers to creative thinking because it does not rely on activating commands, like on a computer; the paperless environment a digital tablet creates increases flexibility for the user to generate ideas [3]; in addition, in her experiment, all participants felt the digital tablet has immense potential for use in the design process to continue to enhance idea generation. So these Electronic sketch tablets, which, like paper and pencil, support unspecified

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input are more appropriate electronic idea creation tools [9]. However, according to Lim [12], due to the cognitive behaviors displayed when using pen-based system and when using conventional pen and paper are different.

3.2. Three-dimensional digital modeling

One of the features and facilities that digital tools have provided to design, especially in the early stages of design, is three-dimensional modeling. The findings of some researches show the importance of integration a 3D modeling to early architectural design phase for producing unique design solutions. In this case, visual design thinking is performed through three dimensional digital models that might be described as sketching in space. Also, according to Haapasalo [10] 3D modeling, from the design point of view is aimed usually at the early phases of design in order to examine and visualize details or larger entities. Using easy to handle 3D modeling software helps to find appropriate design solutions.

Using easy to handle 3D modeling software helps to find appropriate design solutions. For example, the EsQUIsE software provides architects with the possibility to generate automatically 3D views from the freehand drawings that are used for exploring alternative solutions Figs. 3 & 4 [27].

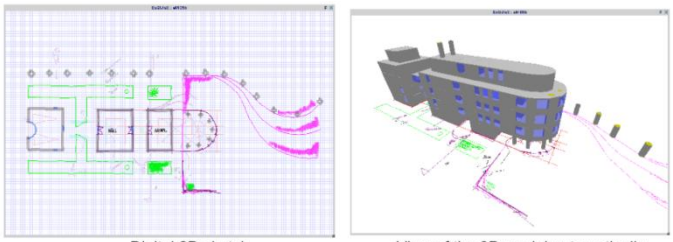


Fig. 3 An overview is drawn on a digital layout with an electronic pen. The architect can then select those of the layout which are relevant to him and ask for an automatic generation of the 3D view (at the right) [27]



Fig. 4 EsQUIsE is used on a graphic tablet [27]

3D modeling sometimes allows the students to understand their own design better and definitely increases their design abilities in a rather short time [26], and this digital model has a good visual impact and gives freedom to the architect to think about objects, space and form on the same screen [23]. But today there may be problems with three dimensions digital modeling, because, digital modeling introduces new possibilities that allow manipulation of forms, while having fewer cognitive roles. According to Lawson [1], "some of 3D forms are relatively easy to generate in CAD but are hard to represent in manual perspective. Perhaps this encourages students to believe that because they have drawn something infrequently seen, they are being creative". This is why digital models are considered as a threat in early phases of design.

4. PILOT STUDY (CURRENT ROLE OF DIGITAL TOOLS IN EARLY DESIGN STAGE; EVALUATION OF ARCHITECTURAL SCHOOLS)

A pilot study is usually conducted to investigate the initial situation of research problem in hand and executed as planned for the future studies but on a smaller scale; so, as a preliminary study, the results cannot be generalized to the whole. The previous discussions and reviewed literature in research area create an interest about the current situation of using digital sketching in architecture schools and educational field. This study in this section, aims to assess and understand how digital sketching tools are used in the early stages of design in architecture schools, as well as kinds of programs and software in real world. Therefore, according to purpose of this section a pilot study was done to obtain the architecture instructors' opinions about research problem.

4.1. Methodology of survey

This survey conducted via online questionnaire that was sent to architecture instructors' emails. The research populations of this survey are the architecture instructors who had research in this field and samples were randomly selected from different university from worldwide. Their email addresses were obtained from their researches.

4.2. Findings of survey

In total 180 questionnaires were sent, only 63 people responded it. The 36 percent of respondents were from universities in Turkey and 64 percent from other countries such as Australia, Brazil, Canada, Belgium, Malaysia, Latvia, Cyprus, Bahrain, and Nigeria. The gender of instructors who responded to questioner were 71.40 percent Male and 28.60 percent Female; Their educational and research areas were generally stated in architectural design and education, design theory, digital and computational design, virtual design Studios, BIM, conceptual designing and ets. They mostly teach to junior, senior and graduate students and few of them have courses to freshman and sophomore students.

The questionnaire in addition to the general questions, consisted of three sections: in the *first* section, instructors were told to answer about their and their students designing tool(s) by four questions: First asks about

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instructors' sketching media when they start to design, second question queries about their students' sketching tools, third question explores instructors' preferred design tools for students and fourth question queries the successful sketching tools for students. Each question consist of four design method that respondents need to rate them.

In the *second* section of questionnaire, totally presented 15 questions as 15 statement that respondents need to rate the degree to which they agree or disagree with them. In programs are used by instructors and their students in the design studios.

In the section one, the instructors' responses calculated and results as percentage shown in Fig. 5. Findings show that the traditional freehand sketching in four questions gained the maximum positive values and has not any negative value. In addition, the working directly with CAAD programs has the minimum positive values.

this section, instructors were told to evaluate digital media in their design studios (Q.1 until Q.6) and its impact on the creativity and successfully of students (Q.7 until Q.10), in some of questions, digital sketching were assessed related to the creativity features (such as fluency, flexibility and originality) (Q.11 until Q.13) and also some questions explore the relationship between designer' sketching tools and their abilities and skills (Q.14 and Q.15). In the *third* section of survey, is asked of which digital design

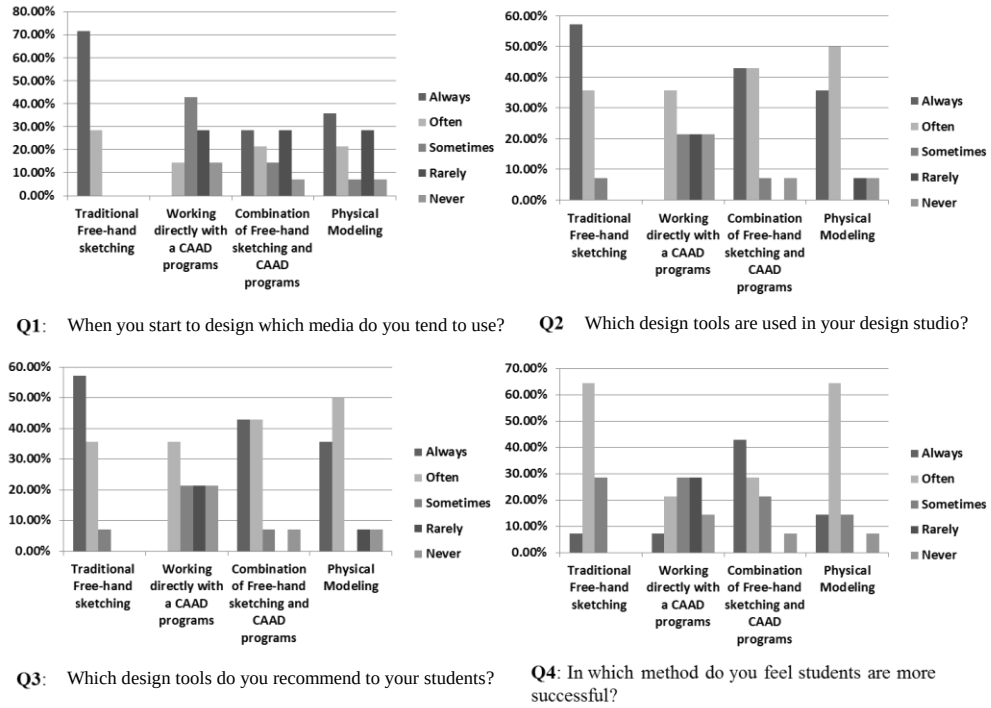


Fig. 5 Questions of first section and percentage of answers

The responses of each participant were evaluated with the Likert analysis method. In this scale method, for 5 point ordinal scale (always to never) was given values from 5 to 1 sequentially. This values for each design and sketching method were calculated. Findings demonstrate that the "traditional free-hand sketching" tool with the highest percentage (100%) has been the common designing tool among the instructors and their students; and "working directly with a CAAD program" got the lowest percentage (50%) in positive tendency. The combining of freehand sketching with CAAD programs has an equal value with physical modeling method (86% positive tendency versus 14% negative tendency) as shown in Table 2 and Fig. 6.

Table 2 Percentage of tendencies of teachers to design tools

Design Tool	Positive Tendency	Negative Tendency
Traditional free-hand sketching	100%	0%
Working directly with a CAAD program	50%	50%
Combination of free-hand sketching and CAAD program	86%	14%
Physical modeling	86%	14%

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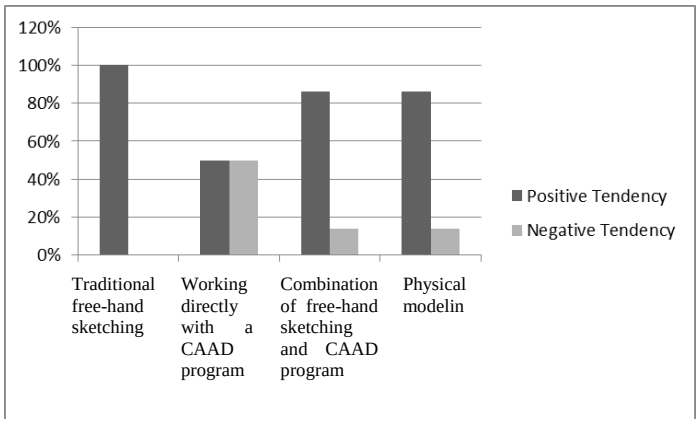
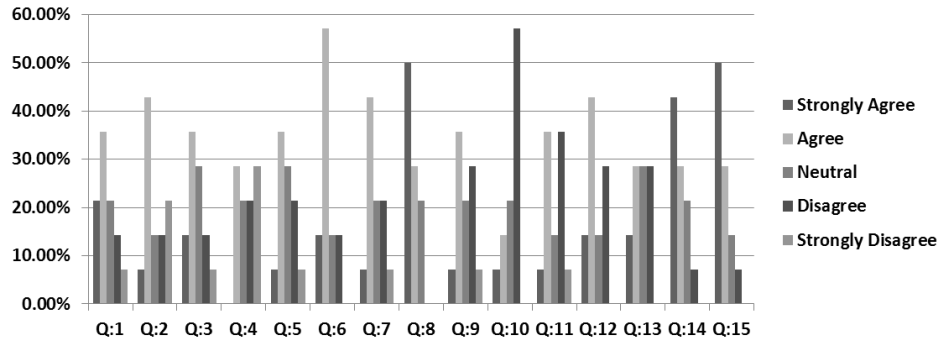


Fig. 6 Percentage of tendency of teachers to design tools

In the second section of questionnaire, the opinions of respondents in agree or disagree with 15 statements as percentage are showed in Fig. 7. In this figure, the opinions of respondents to each statement (strongly agree to strongly disagree) are shown separately as a percentage.



Q:1	Students can think about design problem via digital media in my design studio
Q:2	We must start to teach our students from the outset to design with digital media
Q:3	Students feel more comfortable with digital based sketching.
Q:4	The student spends less time while designing with digital based sketching
Q:5	The Senior students are depended on computer at the early stage of design process
Q:6	Students can express their design thoughts better once they learn digital sketching
Q:7	If computer is used only as a tool it will limit design creativity.
Q:8	If computer is used to enhance design thinking it will help designer in creative design making
Q:9	Most successful students prefer digital based sketching
Q:10	In digital based sketching method I feel students more creative
Q:11	Digital based sketching enhances the students' ability to develop large number of ideas (Fluency)
Q:12	Digital based sketching increases the students' talent to generate various ideas (Flexibility)
Q:13	Digital based sketching increases the students' ability to produce new and unusual ideas (Originality)
Q:14	There is a relation between student's creativity and his ability in designing tools
Q:15	There is a relation between professor's ability in designing tools and his (her) recommended tools to students

Fig. 7 Questions to evaluate instructors' tendency to digital design tools

The results are evaluated with Likert analysis method; in this scale method, for five point ordinal scale (strongly agree to strongly disagree) was given values from 5 to 1 sequentially. The findings show that the sum of instructors' positive opinions related to digital sketching in their design studios (Q.1 until Q.6) is 64 percent, their opinions related the impact of digital sketching in creativity and successfully of students (Q.7 until Q.10) is 66 percent, their opinions about features of creativity in digital sketching (Q.11 until Q.13) is 65 percent and finally the sum of their opinions in Q.14 and Q.15 is 83 percent (as shown in Table 3 and Fig. 8). These show that more than 50 percent of respondents have a positive opinion related to the digital tools in the early stages of design.

In totally, the results are evaluated with Likert analysis method, after calculating the value of each answer for each respondents, findings show 64% of respondents have a positive tendency towards digital tools for supporting creativity, and 36% have a negative opinion.

Table 3 Total values in percent for question groups separately

	Q.1 until Q.6	Q.7 until Q.10	Q.11 until Q.13	Q.14 and Q.15
Total Value	64%	66%	65%	83%

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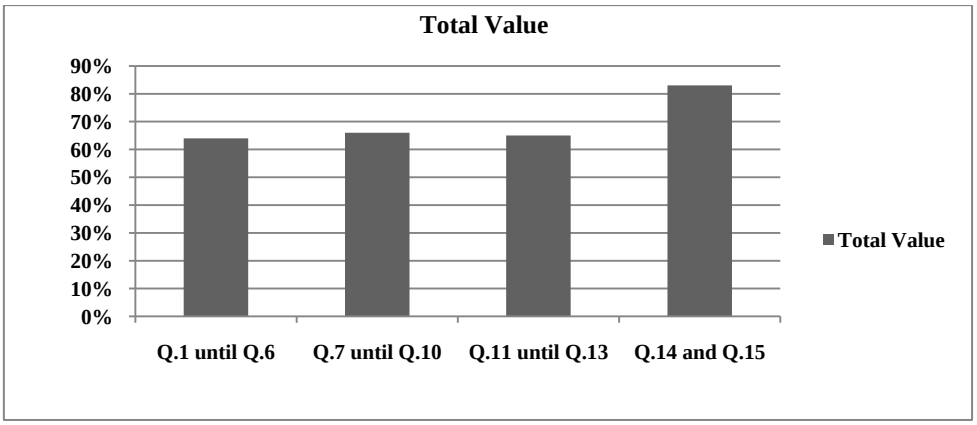


Fig. 8 Total values in percent for question groups separately

In the third section, according to responses, digital programs such as Sketchup, Photoshop, Sketchbook and AutoCAD are the common digital tools that the instructors and their students use and prefer for designing. Other digital tools such as Hyve-3D, Archicad, Bailey Sketch (app), QsketchHDLite (app), Revit, Rhino, Balsamiq SketchiXML and Gambit Invision Axure programs, too, are mentioned.

4.3. Discussions

These results indicate that, freehand sketching is yet common design tools in early stages of design, but in many architectural schools, it is attempts to apply digital sketching tools especially among young students and educators. Findings of survey show some of instructors are strongly disagree with using of digital in the conceptual design, in contrast some of them believe that with advancing in digital technology, these tools should apply to the early design stages and replace paper based sketching. For this reasons, it seems that pen based digital systems and tools due to their similarity to conventional freehand sketching have been attention.

The results of the first section of survey support the theoretical discussions that were posed in previous sections and this is a reflection of the professors' doubts over digital tools that instead of using them directly, they prefer the traditional freehand sketching or the combination of freehand sketching and CAAD program. The result of 50% positive to 50% negative desire to use of digital tools, also confirm that these tools are of interest and cannot be ignored. Although, instructors and students do not commonly use digital tools in the early design stages, but, the findings of second section indicate that, there is a tendency to use this technology among them, that with the advances in the user interface of digital programs and given the potential of these tools, it may be realized in the future times.

5. CONCLUSION

In this study, the current status of digital sketching in early design stage and their challenges in the educational filed, especially related to creativity are explored. Findings indicate that computer by new interfaces began to affect the thought process of designer in the early stage of design that has created a wave of discussions and challenges in architectural research and education. Recent developments in digital tools show a shift toward conceptual design interfaces; but they are still not commonly used in the early design stages. It seems that this returns, on the one hand, to the user interface of digital systems that encourage working with precision and detailed and do not allow vagueness and uncertainty, which plays an important role in conceptual design, and on the other hand, using of digital systems does not match the speed of thinking process of designer unlike the conventional freehand sketching. In addition, in this case the ability of users to use this medium should not be ignored.

Studies show despite to all of these, digital tools can support and enhance creativity. They can encourage creative behaviors and allow stimulating and exploring wide range of design alternatives by rethinking previous ideas and improve them. Therefore, many researchers attempt to propose recommendations to enhance digital systems or new ways of working with them in order to support creativity and sketching. According to researches to provide an interface that feels natural and close to traditional sketching and support creativity, the system must be able to resolve ambiguities and enable the architect to focus on the design problem and not on how to use the program. The emergence of some pen-based sketching systems, has created a strong desire -especially for the younger designers- to use them in the conceptual design phases, while the inadequacy of these software in encouraging ambiguity and creativity, has caused that, many of experienced designers and academics to doubt in using these tools, or even, entirely oppose to use them in the design thinking process.

The results of pilot study in educational field also support the current discussions in research field and theoretical findings that suggest the professors' doubt over digital tools that instead of using them directly, they prefer the combination of freehand sketching and CAAD programs. However, findings indicate that there is a tendency to use these tools among educators and their students. It is expected with the advances in user interface of digital programs, in future times, they will be used as designing and thinking tools in the early stages of architectural design at educational context. The

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interdisciplinary researches between architecture, mathematics and computer science can create proper solutions for these problems.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

NOTE

1. For more study about some of these tools see [14], [16]

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