

# The Effect of Conventional and Digital Drawing Tools on Imagination in Architectural Design Education

● **Dr. Amjed M. Ali**- Ass. Prof. ●  
Architectural Department-University of Sulaimani

**Hawar Himdad** - Asst lecturer  
Architectural Department-University of Koya

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## Abstract



This research investigates the effects of digital drawing tools on imagination in comparison to the conventional drawing tools within the educational frame of architectural design. The significance of this study lays in the critique on the utilization of different digital drawing tools in the educational frame, seeking to find the main effects the different types of tools have on students' imagination. This study has taken imagination faculty as factor since the highest level of mental abilities is found in this specific faculty and design students cannot permit any obstacle in front of their imagination design capabilities. The problem upon which this study is based, beside the fact that the digital technology is a dialectic issue in the educational framework, its effects are also unknown as far as the students' imagination capacities are concerned.

The case study involved the comparison between two groups; one group relying strongly on digital tools while the other depends merely on conventional tools, herein are students' imagination capacities as well as drawing capabilities investigated. Also the teaching staff opinions were taken from each student group by means of a questionnaire. This study has found that there is a positive relationship between drawing and imagination capabilities. And students using conventional drawing tools merely have higher imagination capabilities score as well as drawing capabilities score according to a test and evaluation form designed specifically for this study. The majority of teaching staff found that students with higher capabilities in drawing by conventional tools encompass also higher capability in imagination.

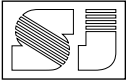
Keywords: Architectural Design, Design Imagination, Conventional Drawing Tool, Digital Drawing tool.

## 1. Introduction

Architectural design has utilized digital technology from the conceptual design phase all the way to the finishing stage. Although the utilization of this implementation is strongly criticized as well as commercially demanded, it is in architectural academics where the strong controversy around the negative aspects concerning the use of these digital tools arises. Modern technology and its inescapable influences have lead to much critique within the academic frame, mostly due to concern about any negative effects on design skills. This issue is of substantial importance in architectural education. Since there are different believes and different attitudes towards the use of digital technology, the main objective of this research is to determine the used technology and come to a recommendation on its application within the academic design process. According to the literature analysis the ideas on the implementation of digital tools in architectural education are divided. While some previous literature find it of major importance to integrate the digital technology in the design education (Salama 2007; Duarte, 2009; Cantrell, 2010; Bates, 2010, , Yee 2013), others oppose strong reliance on digital tools because of uncertainties (Lawson, 2004; Palladino, 2007; Edwards, 2008; Frascari, 2011; Pallasmaa, 2011).

## 2. Research problem

The literature review, which provides data regarding imagination as well as drawing tools, clarifies that it does not cover the effect of



drawing tools on imagination on both theoretical and practical levels. This leads to a case of uncertainty regarding the implementation of these drawing tools. And the deficiency of academic resource initiates the need to emphasize the research problem as; “the availability of thus far undecided denominators to formulate the theoretical framework of effect from digital drawing tools on students’ imagination”.

### 3. Research objectives

The broad objective is to improve architectural education from the technological integration viewpoint. The main objective is to define the effect of implementing digital drawing tools on imagination. This has been divided into sub objectives which are; to find the applicability of digital tools by students, and also to discover the role of design instructors in leading and stimulating creative imagination taking into consideration the characteristics of both types of tools.

## 4. Research terminology

### 4.1. Imagination

The design process consists of three types of thinking; Imagination, presentation and testing (Zeisel, 1984, p.35). And it is generally a constructive perception that includes a recombination of some cognitive activities of normal seeing with visual imagination, which leads to a cognitive tool that is the line sketch (Ware, 2008, p.152). The recognition of a novel method for problem solving involved a balance between both “intuition (imagination, experience, and beliefs) and logic (objectivity, phenomenology, and repeatability)” (Stewart, 2008, p. 57). Imagination is a first tool at hand of the designer (Verbeek et. Al, 2006, p. 393).

“The activity of visualizing ideas is a combination of perception and imagination. Although mental images often appear spontaneously in response to sensory perception” (Baskinger and Nam, 2006, p.1). Flexibility in visual impressions causes a change in the way a perceiver sees an image. The perceiver’s inner organization changes in order to imagine a different image than seen at first or in general (Beaney, 2010, pp.143-148) A distinction of two levels of imagination are made; the creative imagination; “A mental function emphasizes the attributes of initiation and originality in an advanced level of development, this function is present in great discoveries and achievements of human kind” and reproductive imagination; “a

mental function for reproducing images in mind” (Liang et Al., 2012, pp.367-369).

### 4.2. Drawing and drawing tools

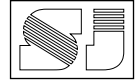
“Drawing is fundamentally a means of vision and expression. It relies on clear vision and requires thought which, in turn, builds understanding. [...] The knowledge and understanding gained through drawing from life directly enhances the ability to draw from imagination. [...] Ideas can be made visible in a drawing to promote visual thinking and further stimulate the imagination” (Ching, 1990, p.5). It is found significantly between the imagination of a designer and the design of a building (Fraser & Henmi, 1994, p. viii).

CAD has drastically transformed the architectural practice (Palladino, 2007, p.X), and in this age of far reaching computer use and rising visual stimulus the implementation of tools should be questioned because of “its influence on the imagination and design process of architects” (Smith, 2008, p.1) “Ideally, digital and analog media find a middle ground, where an exchange of information can occur. As a designer, you need to understand how drawings inform one another in order to make decisions at each stage of representation process. The final result for either medium is to create drawings that accurately represent design ideas, evoke the experiences being designed, and contribute to the design process” (Cantrell, 2010, p.36).

### 4.3. Architectural Education

Drawing is the language of communication and thus of substantial importance for the architectural education (Salama, 2007, p.21). There is an overwhelming tendency to focus on the comparison of drawing tool types; on one hand the large extent of possibilities of digital tool and on the other hand the strong commitment to the qualitative characteristics of conventional tools (Laseau, 2001, p.233).

Although the digital drawing tools are a small portion of all the given tools, the commercial needs to keep up with the modern progresses has caused a large number of architectural schools inline towards the use of digital media (Alkymakchy, 2011, p.25). According to Visser are hand-made sketches and model-making considered indispensable for the creative process, as they seem to support ambiguity in early concept outlining (Acunaet. Al, 2011, p.265), and “designers report having a kind of conversation with their sketches” (Tversky et. Al., 2011, p. 211). However digital representations can be deceitful, but



sensibilities needed to draw well and to design well are so related that this barely could happen (Lawson, 2004, p.75).

“The lack of a “natural” feeling is specifically attributed to the hardware and software that mediates our ability to directly manipulate the drawing surface and/or media using our hands. The main advantage of digital media is its editability and efficiency. A drawing created digitally is no more editable or efficient than an analog drawing unless the tools are used correctly. This requires the designer to use a process that is both systematic and natural. It is important to define what is meant by the terms editability and efficiency” (Cantrell, 2010, p.17).

It is unfortunate that hand drawing techniques are still largely taught as time intensive rendering techniques (Richards, 2013, p.25), because there is need to draw quickly at the early conceptual levels and being finally illustrated by the great advantages of the digital media. “The focus should then not be on specific rendering techniques but rather at visual thinking and rapid visualization (Richards, 2013, pp. 25-27). “CAD is not only rarely employed as a design tool at the early stages of concept gestation by the country’s senior architects, it is felt by many to hinder initial design investigation. Several architects deliberately avoid its use until the building has been relatively resolved by other means. In fact, the view expressed by some was that the use of CAD too early undermined architectural exploration and had a detrimental effect on the quality of architectural thought” (Edwards, 2008, p.258). “Available tools are generally intended for use by professional developers to improve productivity and are not suitable for educational purposes. Tools are generally difficult to learn and use, are confusing to beginners, and ignore educational aspects” (Ramollari and Dranidis, 2007, p.363).

#### 4.4. Mind and bodily actions

“Despite the magical interactions, tools are not innocent; they expand our faculties and guide our actions and thoughts in specific ways to argue that for the purpose of drawing an architectural project the charcoal, pencil, ink pen, and computer mouse are equal and exchangeable is to misunderstand completely the essence of the union of the hand, tool and mind” (Pallasmaa, 2011, p.50). Goldschmidt maintains that hand sketching is an extension of mental imagery, while a drawing made by hand is a tool for designers thinking processes (Goldschmidt, 2003, pp.72-76). “The ideal sketches are those that evolve from intuition

indirectly guiding the hand, more than the mind directly guiding the hand. Also, combinations of images and words enrich the process. Freehand conceptual sketching is the most potent means of generating ideas for any type of design. It is unlikely that any medium will fully supplant the immediacy and directness of freehand drawing (Yee, 2013, p.68).

Different types of media directly influence the feeling of space that is perceived (Yee, 2013, pp. 74-75). The act of drawing is in a way analogous to touching. When students draw, they begin by imagining their pencil is actually touching the surface of the figure (Cooper, 2007, pp.10-11). Touch is the parent of senses. It is the sense which became differentiated into the others, a fact that seems to be recognized in the age-old evaluation of touch as the mother of the senses” (Pallasmaa, 2012, p.12). “The eye is the organ of distance and separation, whereas touch is the sense of nearness, intimacy and affection” (Pallasmaa, 2012, p.50).

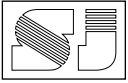
#### 4.5. Drawing and creativity

According to Haapsalo is creative architectural design “just the same as any other creative thinking or design. That what a human does, but a robot is not able to do” (Haapasalo, 2000, p. 117). The creative imagination requires a dedicated strength in visualization and an understanding of the flexibility in drawing offer new problems and answers (Ching, 1990, p.192). According to Ching creative drawing relies on the following criteria: intuition, fluency, flexibility, ambiguity. (Ching, 1990, pp. 184-190). But it is the simplicity of tool that seems to be significant for inspiring the creative drawing process (Frascardi, 2011, p. 53 and Richards, 2013, p. 27).

“Understanding mental images is critical because design is a creative process wherein some parts are done as mental images, and some parts are done by a sort of hybrid between mental imagery and normal seeing where design elements are cognitively added to incomplete sketches” (Ware, 2008, p.150). Since lack of ability in drawing “can limit visual and spatial imagination, it follows that drawing lessons take a central position. Just as a successful writer must have verbal skills, the designer needs visual expression skills to be creative” (Tschimmel, 2011, pp.227-228).

#### 5. Research hypotheses

The need for design education to find a proper integration of tools is essential due to the relation between drawing and drawing tool. Since any



product, as well as process, is affected by the used tools that are considered mediums, there cannot be predicted that there is no relation between digital drawing tools and the design skills, thus;

(H1) "There is strong positive relation between drawing tool type and imagination."

(H2) "Different types of digital drawing tools have different effects on the students' imagination"

(H3) "The creative imagination is necessary for visualization skills as well as the drawing skills"

(H4) "Freehand drawing and design grades are in close relation due to the relation of hand drawing and imagination and the substantial need of imagination for design"

(H5) "The use of digital drawing tools emphasize reproductive imagination, while the conventional drawing tools boost the creative imagination."

## 6. Methodology

After a survey in previous literature this study followed an explorative practical approach in order to test the hypotheses.

### 6.1. Research population

There were two categories of participants in this research, a consensus of 4th and 5th year architectural students of Koya University and University of Sulaimani as well as their teaching staff of architectural design subject .

### 6.2. Data collecting tools

The main criteria used as a basis for this section is according to indicators from table 3.

- Students evaluation form; Students are evaluated individually according to an ordinal measurement, whereas (1) means low, (2) means medium and (3) means high. The Evaluation is based on the main 9 criteria of Reproductive- and Creative Imagination (See table 10) aiming to investigate the nature of relation between the two levels of imagination. As well as their preferences considering the digital and conventional drawing tools.
- Imagination test; A test is designed in order to examine the students according to the main indicators of imagination. The test consists of several parts. The test contains a personal introduction (see table 1) and personality assessment (see table 2). As well as two categories, simple and a complex , measurements of the mental rotation abilities (see table 3 and 4).. Another category is

testing the creative imagination of students (see table 5), (TCI-test) . Then the visual flexibility (see table 6) of students is tested according to multi organizational images . The test ends with two drawing based categories; one is drawing from imagination where the student is asked to draw a personal previously designed project (see table 8) and the other is visualized drawing where the student is asked to draw from the arrow point of view (see table 7). The face validity of the imagination test is tested beforehand by teachers of psychology and educational psychology. See table 1 for an insight on the content as well as scoring

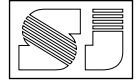
- Students' grades form: For investigating the level of relation between the drawing skills and students' design skills another indicator is included in this study which are the grades of the subject "Free Hand Drawing" and "Architectural Design". For the subject of free hand drawing the grades of first stage and the second stage are taken for both fourth and fifth stage students. First to third stage design grades are taken for the fourth stage students and first to fourth stage design grades are taken for the fifth year students .
- -Teachers questionnaire in December 2013: A questionnaire is designed in order to get an insight on the opinions of the teaching staff of Architectural Department/ University of Sulaimani and Architectural Department/ University of Koya. Their personal ideas about different drawing tools as well as their relations with design and imagination are investigated through this questionnaire.

## 7. Results

### 7.1. Students evaluation form

The indicators from this section were analyzed compared to one another as well as the imagination test results and grades, since the same students were involved in all 3 sections.

- Creative imagination indicators (see table 10): Exploration and Novelty showed a very weak positive relation ( $r=0.279$ ;  $r=0.292$ ) with the total number of design including digital tools. Whereas Exploration, Intuition and Novelty also show weak to moderate positive relationship ( $r=0.254$ ;  $r=0.326$ ;  $r=0.253$ ) with the students' familiarity in Revit, as all the imagination indicators except for Crystallization show a very weak to weak positive relation with SketchUp. The very



- weak negative relationship ( $r=-0.211$ ;  $r=-0.245$ ) there is with 3DMax is also to be noted here. This can be evidence for a relationship between imagination indicators and the types of digital tools used by the students in the course of their designs. Hypothesis H3 may be confirmed to some extent.
- Brain dominance (see table 2): As for the personality assessment; Exploration, Novelty and Crystallization show a very weak negative relation ( $r=-0.234$ ;  $r=-0.243$ ;  $r=-0.207$ ) with the left brain score consequently showing a very weak positive relationship ( $r=0.234$ ;  $r=0.243$ ;  $r=0.207$ ) with the right brain score. Novelty of ideas and explorative characters are creative indicators and the right brain hemisphere being responsible for the creative human capacities could explain this relation.
  - Imagination criteria (see table 10): The Mental rotation abilities show a weak positive relation ( $r=0.444$ ;  $r=0.494$ ) with Exploration and Novelty, while showing weak positive relationships with the other indicators. And the relations with the complex mental rotation score was in general lower. As for the TCI test (score C); Novelty, Productivity and Exploration show significantly a moderate positive relationship ( $r=0.381$ ;  $r=0.333$ ;  $r=0.313$ ). The Visual flexibility shows the strongest relation with Exploration ( $r=0.426$ ), with Novelty coming at the second place ( $r=0.372$ ); all other indicators come at the third place except for Transformation that shows no significant relationship. The cohesion between the students' test scores and teachers' evaluation is noted here, since mostly creative imagination indicators are in positive relation with the imagination test scores. But given that also the reproductive indicators are involved here, these cannot be excluded. This finding shows the need of both, creative and reproductive capabilities for the imagination capabilities.
  - Drawing skills: As for the drawing skills, Novelty and Crystallization show a weak positive relation ( $r=0.487$ ;  $r=0.432$ ) with the Visualized drawing. While the Drawing from imagination scores relate moderately positive to Novelty ( $r=0.500$ ), Exploration ( $r=0.473$ ), Sensibility ( $r=0.449$ ) and Elaboration ( $r=0.359$ ) positively, although all other indicators show a moderate strong correlation. Thus it can be noted that a

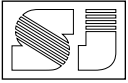
stronger relation exists between the scores and the creative imagination indicators compared to the reproductive imagination indicators. Consequently, according to the last two findings H4 could probably be verified.

- Levels of imagination: As far as the comparison of the two groups goes; the T-test shows a significant to highly significant difference between the imagination indicator evaluations ( $t\text{-test}=2.286-4.213$ ). However the evaluation was conducted by four different teachers, the results have shown the mean average score for n1 is significantly higher than for n2. Another significant difference between the two is the conventional drawing tool use as well as their capacities in these, which show a highly significant difference where n1 score higher in these as well ( $r=0,582$ ). Also the Pearson correlation coefficient is showing a moderate positive relationship ( $r=0,585$ ) between the creative and reproductive imagination. (n1) are estimated to encompass a higher level of both creative and reproductive imagination. This group is also considered to have better skills in conventional drawing tools. This may perhaps validate hypothesis H1. But since there is strong positive correlation between the two levels of imagination and the high score of the n2 group has not lead to higher scores in the reproductive imagination indicators, hereby H5 may possibly be rejected.

## 7.2. Imagination test

See some student data in (Table 2)

- Drawing tool capacities and preferences: Frequency analysis showed that n1 group believe their capabilities are higher in AutoCAD while the n2 group finds a higher capability in 3Dmax. As for the Chi-square test, this shows that there is a strong relation between the universities and the students' familiarities in 3DMAX as well as SketchUp. Sketchup is related to the n2 ( $\text{Chi-square}=14.877$ ) while the 3DMAX is merely related to the n1 ( $\text{Chi-square}=41.882$ ). Regarding H3, this can refer to different influences varying tools.
- The imagination criteria: The results from the imagination criteria from the test included imagination capabilities and drawings by students. According to the frequency analysis a higher left brain score



was noted in n2 compared to n1. However the T-test showed that this difference was insignificant ( $t\text{-test}=0.241$ ,  $P\text{value}=0.810$ ), the left-brained students gain lower score in all imagination criteria. This phenomenon could be explained by the proposal of the right brain hemisphere being responsible for the creative human capabilities; this finding in relation to H3 could magnify the need for creative imagination in visualization skills.

Higher Simple mental rotation score was noted in n1 compared to n2. Higher Complex mental rotation score was noted in n1 compared to n2. The differences between the two groups are highly significant in the simple mental image score ( $t\text{-test}=3.911$ ). The correlation between the simple and complex mental rotation is noted to be moderately positive in nature ( $r=0.421$ ). Another statistically significant relation here is the weak to moderate positive relation between the simple mental rotation abilities and both levels of imagination as well as the two drawing categories. The simple mental score can be seen as a good indicator for measuring the mental rotation capacities as well as indication the capability in drawing from imagination and visualized drawing.

As for the Test of Creative Imagination; the score of scale A was higher in the n2 group while the B scale was higher for the n1 groups and the C score was similar. While, according to the T-test, all the three criteria show no significant differences. All three scores have a weak to moderate positive relationship with the total number of designs for the n1 group. In addition the C score indicating the novelty of ideas has a moderate positive relation with the total numbers of designs including digital tools for the n1 group. This criteria also shows a very weak to weak positive relation with all the indicators from levels of imagination. However the TCI was left blank by many students, for the participants of this section, it is important to note the correlation with the total numbers of designs as well as Novelty and other imagination criteria. Meaning that the novelty of ideas is depending on one another, which could prove the consistency of the used measuring tools.

The A criteria shows a moderate positive relation with only Drawing from the imagination. While the B criteria shows weak to moderate positive relations with most imagination criteria as well as the imagination level indicators. For the Visual impression flexibility, the image interpretation A score of recognizing organizations was higher for the n1 group, while the n2 group had a slightly higher score in the B score. This category being

divided into two criteria A for seeing excising organizations and B for seeing non-existent organizations, show no significant relations compared to one another. This can justify the proposal that the flexible capability of seeing more than one organization in images is a creative imagination capacity.

Concerning the two drawing categories, the n1 group scores higher than the n2 group in both sections. However, for the visualized drawing the differences are according to the T-test considered significant ( $t\text{-test}=2.481$ ) and the drawing from imagination section is seen as highly significant ( $t\text{-test}=6.247$ ). The visualized drawing criteria show weak positive relation with Sketchup capabilities ( $r=0.457$ ) and weak negative relation with 3D MAX capabilities ( $r=0.491$ ). As these findings may validate H3.

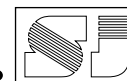
### 7.3. Students grades' evaluation results

This section discusses the relations between the Architectural Design grades and Freehand Drawing grades, these grades are also in relation with some other criteria of the imagination test;

- Freehand drawing grades: There is a general a weak to moderate positive relation between the average design grades and the average freehand grades. According to Spearman correlation the design grades of first, second, third, and fourth stage show significant moderate positive relation ( $r=0.303$ ,  $r=0.443$ ,  $r=0.634$ ,  $r=0.483$ ) with both freehand grades from first as well as second stage. Applying this data to H4, assumably approves this hypothesis.
- Levels of imagination: The third design stage grades show a moderate positive relation with the creative imagination and a weak positive relation with the reproductive imagination. However only in one stage, but this correlation does emphasize the essence of imagination indicators for design performances and the creative imagination in specific.

### 7.4. Architectural Design Teacher questionnaire

- The opinions on architectural curriculum: The teachers from University of Sulaimani have a higher choice (64%) in the need for the architectural curriculum to affect the students thinking "The curriculum should affect the students' design thinking in order to generate a successful architect", while the Koya university staff chooses the answer



“The curriculum should fit what is required from students in the excersize of architectural profession” (56%). According to this finding it could presumably be concluded that the teachers of University of Koya have the tendency to choose the architectural profession merely above affecting students’ design thinking.

- Computer and digital drawing tools: For the question about the teachers’ familiarity with different digital drawing tools, the teachers of both universities have similar capabilities in digital tools. As for the role of computer in the design process: A modeler and drafter are preferences of Sulaymani University staff, while Koya University staff prefers the computer as a critic and as drafter. Whereas about the role of digital drawing tools in academic design, both groups side with the proposal of the design value to be increased by computers. The teachers’ preferences between conventional and digital drawing tools shows the obvious opinion of majority of the teaching staff preferring both types of tools in the design process. The consensus of the teachers to start the use of digital drawing tools in the third academic year, while the highest frequency (78%) prefer the use of these tools to be starting at the presentation phase of the design process.
- How digital drawing tools affect students: In the teachers view, digital tools affect the students’ capabilities. The t-test showed significant differences between the teachers’ ideas as far as the effect on creative capacities goes, where positive influences are merely given by the Koya university teaching staff (t-test=2,760). And also the differences of opinion lay in the imaginative capacities (t-test=2,906), where a large number of teachers from Sulaymania believe in a negative influence.
- Drawing characteristics: On the question what types of drawing affect the imagination the most; Sulaymania teaching staff chooses respectively sensory unavailable drawing, antonymous drawings as well as much time consuming drawings. While the Koya teaching staff chooses antonymous drawings, unambiguous drawings and fixed scale drawings. The frequency analysis shows a relation between the university and the teachers’ choice as far as the “sensory unavailable drawings” goes, since Univeristy of Sulaimania teachers seem to agree that these will evoke the imagination capacities.

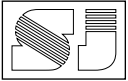
The answers to this question show a consensus of the idea that antonymous drawing stimulates imagination.

- Relation between drawing- and imagination abilities: On the question of “Do students’ drawing capacities relate to the students’ imagination capacities?” the answers were that the majority (85%) of both groups finds that there is a positive relation. And the question of “In your opinion, what student has more imagination?” the answers stated that most of the teachers believe that the capability to draw well by hand implies imagination more.
- Productive and reproductive imagination: According to the Sulaymania teaching staff, the conventional drawing tools are most intuition, sensibility and novelty promoting tools. And the digital tools are more helping with crystallization. The Koya teaching staff finds the conventional drawing tools helping imagination through feelings as well as the promotion of novel ideas. The preceding data indicates that the teaching staff groups do differ slightly from each other. For instance the Koya teaching staff believes the digital drawing tools help the student to be more productive by helping with multiple design concepts.

## 8. Conclusions

### 8.1. General conclusions

Imagination is a substantial ability required in both the education process in general and design education in specific. The architectural education should focus on the process of the design rather than the end product, although a fair balance should be created between the education and the architectural profession. Architectural students should gain data from multiple fields of knowledge in order to be prepared for the complex future tasks awaiting him/her at the design profession, a certain amount freedom could perhaps help for stimulating his/her imagination whereas the scientific, social, technological..etc. knowledge will educate the fresh eyes which is needed for creative thought. The architectural drawings produced during the design process give an insight on the students’ imagination abilities and improve these abilities at the same time. Imagination’s role is substantial in both drawing as well as design. And in the design process is there need for using both types of tools, but according to this research and within its limitations, there can be stated that the strong



reliance on digital tools for young students have shown negative indications.

## 8.2. Research conclusions

1. The students' use of digital tools is in general higher than the usage for conventional drawing tools.
2. The most common digital drawing tools are AutoCAD, Revit and 3d-max. While the familiarities differ from one university to the other, the students and teachers of the same department have similar level of familiarity in the three tools. However the results regarding the students familiarity suggest a relationship between the types of digital tools used by the student and their scores in the imagination criteria, where SketchUp seems to have positive influence and the 3DMAX a negative influence.
3. Students prefer the start of using digital drawing tools at the improving concept phase while the teachers prefer this start to be at the presentation phase. This difference of opinion lays could relate to the prediction that young architects are merely comfortable with using digital tools.
4. The brain dominance theory, in this study, shows strong relations between the drawing capacities as well as the scores in the imagination criterion. Since the right brained students have higher scores in both sections.
5. Since this study consisted of the comparison between two student groups, one group being obliged by the department to present the design works make by conventional drawing tools and the other being left free to choose the used media. There could be stated that the obliged group scores higher in general in both sections of imagination and drawing.
6. Design teachers seemingly create a good insight in students' capacities as well as preferences regarding the different tools throughout the academic year, since there was a cohesion noted between students' scores and the teachers' evaluation.
7. Design's logical as well as intuitive aspects are kept as a preferring design definition for both of the teaching staff groups. The differences of opinions were mostly noted regarding the effect of digital tools on creative capacities as well as imaginative capacities.
8. As for the role of the computer in the design process both teachers' groups agree on the possibility to increase the design value by the computer use. But they disagree on the

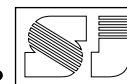
statement that the designer using digital drawing tools remains an outsider of the design process.

9. The level of negative influences of digital drawing tools on students' capacities is higher for one teaching staff while lower for the other, which goes parallel with the departments requirements regarding students use for these tools.
10. All teachers believe there is a relation between imagination capacities and drawing capacities. They also seem to agree that students able to draw well by use of conventional tools are more imaginative than students who are able to draw well by using digital drawing tools.

## 9. Recommendations

1. Architectural students should be admitted according to an aptitude test as well as a personality assessment beside their high school grade averages.
2. The simplicity in tools during early design stage as well as early academic years is highly recommended, this goes for conventional tools as well as digital drawing tools.
3. The architectural education should keep the creative imagination capacities of students in mind throughout the curricula.
4. A balance should be made between the academic frame as well as the professional frame, they should strengthen one another.
5. There is need for students to draw more; a method applied in many universities that are open to the idea of digital drawing tool usage is that each student keeps a personal logbook/sketchbook and this is also a requirement during the design presentations and subject to evaluation.
6. Intuitive drawings should be improved during the early architectural education. Since they stimulate the visualization and imagination. These drawings are merely conduction by means of simple tools that become a second nature.
7. To start a design process as intuitive and holistic as possible remains one of the pillars of creative design process.
8. Teaching staff should be highly familiar with several digital drawing tools, in order to help students as well as evaluate their designs.
9. Outlook : In order to corroborate the results of this study, future research should investigate digital drawing tools and their characteristics in specific to discover which of

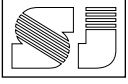




these tools fit the need for architectural education the best. A more effective approach for the integration of both tool types could be investigated in larger samples, possibly complementing it with other theoretical frameworks.

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## تأثير أدوات الرسم التقليدية والرقمية على التخيل في تعليم التصميم المعماري

د . أمجد محمد علي - استاذ مساعد  
قسم الهندسة المعمارية - جامعة السليمانية  
هاوار هيمداد - مدرس مساعد  
قسم الهندسة المعمارية - جامعة كويه

ملخص البحث يهدف هذا البحث الى العثور على تأثير أدوات الرسم الرقمية على التخيل بالمقارنة مع أدوات الرسم التقليدية ضمن الإطار التعليمي . وسعت استخدامات التكنولوجيا وأدوات الرقمية بشكل خاص مجموعة من أساليب التصميم خلال العقدين الماضيين . وقد استخدم التصميم المعماري هذه التقنيات ابتداءً من مرحلة الفكرة الاولى وانتهاءً بمرحلة التنفيذ و للمسات الأخيرة . وعلى الرغم من أن استخدام هذا التطبيق انتقد بشدة ، إلا انه وفي الوقت ذاته هو مطلوب في سوق العمل وقد تنامت في الأوساط الأكاديمية المعمارية خلافات كبيرة حول الجوانب السلبية المتعلقة باستخدام هذه الأدوات الرقمية . من هنا جاءت أهمية هذه الدراسة التي تسعى الى العثور على تأثيرات الأنواع مختلفة من الأدوات ، التقليدية والرقمية ، على التخيل لدى الطلبة .

وقد اتخذت هذه الدراسة عامل الخيال لانه يحتوي على أعلى مستوى من القدرات العقلية والنفسية ، و هو ذو أهمية فائقة لدى طلبة القسم المعماري . المشكلة التي تستند إليها هذه الدراسة : هي ان ظاهرة استخدام التكنولوجيا الرقمية قضية جدلية في إطار التعليمي ، وآثارها على قدرة التخيل لازالت مجهولة . وشملت حالة الدراسة مقارنة بين مجموعتين ؛ احدهما اكثر اعتمادا على الأدوات الرقمية ، في حين تعتمد الاخرى على الأدوات التقليدية فقط ، ويتم هنا التحري عن قدرات التخيل لدى الطلاب وكذلك قدرات الرسم . وقد تم تصميم اختبار متخصص لتقييم قدرة التخيل والرسم لدى الطلاب وفي الوقت نفسه تم تقييم مستوى تخيل الطلاب من قبل اساتذة التصميم من خلال استمارة تقويمية (والذي تكون من مجموعتين من المؤشرات : مؤشرات التخيل الابداعي و مؤشرات التخيل التوالدي) . كما تم أخذ آراء هيئة التدريس حول كل مجموعة من الطلاب عن طريق الاستبيان .

وجدت هذه الدراسة : ان هنالك علاقة إيجابية بين الرسم وقدرات التخيل . والطلبة الذين يستخدمون أدوات الرسم التقليدية بكثره تكون درجة قدرات التخيل وقدرات الرسم لديهم اعلى . ووجد ايضا ان هنالك علاقة ايجابية بين التخيل الابداعي و التخيل التوالدي ، كما ترى هيئة التدريس ان الطالب اللذي لديه قدرة عالية في الرسم بالأدوات التقليدية تكون لديه قدرة تخيل اعلى .

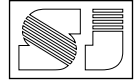


Table 1 Table showing the personal data questions (Source: Researcher according to theoretical survey)

<b>Verbal Directions</b>	"This category consists of 11 questions designed to get an insight on your personal experiences and preferences concerning drawing tools, please read the questions carefully and answer as specific as you can." (15 minutes)
<b>Question 1 Description</b>	<b>Name:</b> Here the student writes down his/her full name
<b>Question 2 Description</b>	<b>Stage:</b> The year of education is to be noted
<b>Question 3 Description</b>	<b>Gender:</b> The student chooses between (male) and (female)
<b>Question 4 Description</b>	<b>What is the number of projects you have designed until now?</b> The student noted the number of academic projects and if the case professional projects.
<b>Question 5 Description</b>	<b>What is the number of projects you have designed only using conventional drawing tools?</b> The number of project the student has designed using only conventional drawing tools is to be noted
<b>Question 6 Description</b>	<b>What is the number of projects you have designed using digital drawing tools?</b> The number of projects the students has designed using digital drawing tools is noted
<b>Question 7 Description</b>	<b>In your opinion how much do you use conventional drawing tools and how much do you use digital drawing tools? Please specify the percentages</b> The student will note the percentage of using conventional tools and digital tools, the summation of the two percentages should be 100%
<b>Question 8 Description</b>	<b>According to the design process, when do you think it is the best moment for using digital drawing tools?</b> The student chooses between three main steps in the design process; Concept phase, Improving concept phase, Final presentation phase.
<b>Question 9 Description</b>	<b>Are you familiar with the following digital drawing tools?</b> The student is asked about five most common digital drawing tools and for each of the five the student chooses between 4 levels of familiarity; not familiar, low familiarity, medium familiarity and very familiar.
<b>Question 10 Description</b>	<b>According to the five academic years in architectural education, when do you think it is the best to start using digital drawing tools?</b> The students chooses between the stages;1,2,3,4 and 5.

Table 2 Showing the personality assessment (Source: Researcher according to theoretical survey)

<b>Verbal Directions</b>	"This category consists of 14 questions which are meant to investigate how you act in general around your tasks. Please choose an answer between A and B the answer that is the closest to your general way of acting." (15 minutes)
<b>Question 1 Description</b>	<b>How did you end up wearing these clothes today?</b> The student chooses from: A- I prepared it yesterday (The students gets 1 point in the Left brained scoring) B- By complete accident (The student gets 1 point in the Right brained scoring)
<b>Question 2 Description</b>	<b>If you could work in the movie world, you would....</b> The student chooses from: A-You would rather be the lead actor (The students gets 1 point in the Left brained scoring) B-You would rather be the director (The student gets 1 point in the Right brained scoring)
<b>Question 3 Description</b>	<b>When you watch a sad movie...</b> The student chooses from: A- You get emotional (The student gets 1 point in the Right brained scoring) B- You are in complete control of your feelings (The students gets 1 point in the Left brained scoring)
<b>Question 4 Description</b>	<b>What is the best way for you to finish your design project?</b> The student chooses from: A- I first draw the concept, then the plans, then the elevations, then the sections and perspectives. (The students gets 1 point in the Left brained scoring) B- I jump from one sheet to the other (The student gets 1 point in the Right brained scoring)
<b>Question 5 Description</b>	<b>In your opinion, is there in general method to evaluate a design project?</b> The student chooses from: A- Yes, there is a right and wrong way for designing. (The students gets 1 point in the Left brained scoring) B- No, the evaluation depends on the situation (The student gets 1 point in the Right brained scoring)

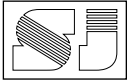


Table 2 Showing the personality assessment (Source: Researcher according to theoretical survey).

<b>Question 6</b>	<b>How do you behave during your design presentations?</b> The student chooses from:
<b>Description</b>	A- During the presentations I have a hard time expressing my ideas verbally so I tend to talk and point at my work on the wall a lot. (The student gets 1 point in the Right brained scoring) B- During the presentation I am in control of my speech about my work without referring. (The students gets 1 point in the Left brained scoring)
<b>Question 7</b>	<b>How would you like to feel while designing your projects?</b> The student chooses from:
<b>Description</b>	A- I take risks during my designs (The student gets 1 point in the Right brained scoring) B- I like to feel as not being at risk (The students gets 1 point in the Left brained scoring)
<b>Question 8</b>	<b>How do you take important design decisions?</b> The student chooses from:
<b>Description</b>	A- Based on logic (The students gets 1 point in the Left brained scoring) B- Based on intuition (The student gets 1 point in the Right brained scoring)
<b>Question 9</b>	<b>In what design stage do you find yourself most comfortable?</b> The student chooses from:
<b>Description</b>	A- During conceptual phase (The student gets 1 point in the Right brained scoring) B- During working drawing phase (The students gets 1 point in the Left brained scoring)
<b>Question 10</b>	<b>During your design critiques, how well do you understand the teachers' opinions on your design?</b> The student chooses from:
<b>Description</b>	A- I usually understand them (The student gets 1 point in the Right brained scoring) B- I don't understand them very well (The students gets 1 point in the Left brained scoring)
<b>Question 11</b>	<b>At what position do you get the best design ideas?</b> The student chooses from:
<b>Description</b>	A- In sitting position (The students gets 1 point in the Left brained scoring) B- In a casual position, such as lying down. (The student gets 1 point in the Right brained scoring)
<b>Question 12</b>	<b>Which subjects do you prefer?</b> The student chooses from:
<b>Description</b>	A- Design, Freehand drawing, perspective (The student gets 1 point in the Right brained scoring) B- History, Working drawing, Building estimations, housing. (The students gets 1 point in the Left brained scoring)
<b>Question 13</b>	<b>Imagine, your design teacher tells you to come up with a new concept. How do you react?</b> The student chooses from:
<b>Description</b>	A- You become very mad, because you have been working on this concept very hard. (The students gets 1 point in the Left brained scoring) B- You get excited, because you already have a new concept in mind (The student gets 1 point in the Right brained scoring)
<b>Question 14</b>	<b>What part of a building is most important for you?</b> The student chooses from:
<b>Description</b>	A- The sense it imprints on the people. (The student gets 1 point in the Right brained scoring) B- The service it offers the people (The students gets 1 point in the Left brained scoring)

Table 3 Giving a scope of the designed test for students, regarding the simple mental rotation test (Source: Researcher according to theoretical survey)

<b>Verbal Directions</b>	This category consists of 10 questions designed to see how well you can visualize the rotation of three-dimensional objects. Try to find the right answer between A, B, C, D and E. (15 minutes)
<b>Example of question</b>	
<b>Scoring</b>	Each multiple choice question has only one good answer, for each good answer is 1 point given. The total score of second category is 10 points.

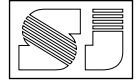
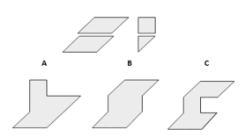
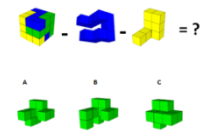
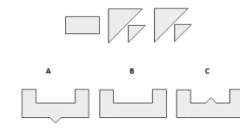
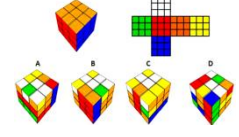
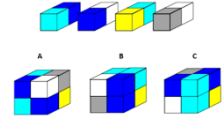
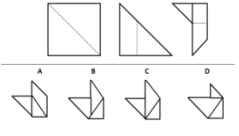
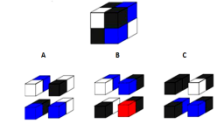
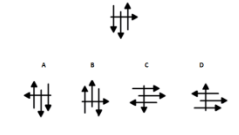
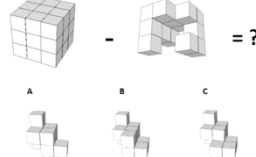
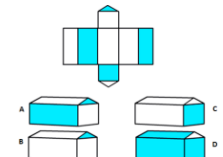


Table 4 Giving a scope of the designed test for students, regarding the complex mental rotation test (Source: Researcher according to theoretical survey).

Verbal Directions	This category consists of 10 questions designed to see how well you can visualize the rotation of three-dimensional objects. Try to find the right answer between the given choices. (10 minutes)	
Question 1	<p>The shapes on the top combine to make one of the shapes below, which one?</p> 	Question 6
Description	The right answer is A	 <p>The right answer is C</p>
Question 2	<p>The shapes on the top combine to make one of the shapes below, which one?</p> 	Question 7
Description	The right answer is A	<p>With only three turns on a rubiks cube which of the four cubes are possible to attain? See the cube folded and unfolded below.</p>  <p>The right answer is B</p>
Question 3	<p>One of the groups of bricks below combine to make the cube shown, which one?</p> 	Question 8
Description	The right answer is C	<p>A piece of square paper is folded along the dotted lines as shown below. If you continue folding along the dotted line, which will result?</p>  <p>The right answer is C</p>
Question 4	<p>One of the groups of bricks below combine to make the cube shown, which one?</p> 	Question 9
Description	The right answer is B	<p>Which figure is identical to the first?</p>  <p>The right answer, A B C and D</p>
Question 5		Question 10
Description	The right answer is B	<p>Which figure is identical to the first?</p>  <p>The right answer is A</p>

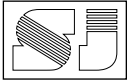


Table 5 Showing the Test for Creative Imagination (Source: Researcher according to theoretical survey)

<b>Description</b>	<p>A test sheet is an A4-sized sheet of paper with 16 elements divided four four-element sets- straight lines, dots, curvy lines and semi circles.</p> <p>This category measures the following indicators;</p> <ul style="list-style-type: none"> <li>-Novelty, the level of originality in ideas.</li> <li>-Productivity, the number of ideas</li> <li>-Transformation, the flexibility of thought.</li> <li>-Elaboration, the level of elaboration in the drawings. (30 minutes)</li> </ul>
<b>Verbal Directions</b>	<p>“In this category you find a sheet of paper with 16 figures drawn on it. These are four lines, four dots, four curvy lines as well as four semicircles. Please try to use these elements to draw as many schematic drawings as you can that represent something that does not exist but in your opinion should exist. These might be new appliances, medicines or inventions, but also schematically expressed ideas and so on. The subject of the drawings is not limited. You can use all the sixteen elements or fewer in your drawings, but you cannot use more than the given sixteen figures in each of the drawings. Please try to draw as many such pictures as you can and make sure they are as original as possible. We will not rate your artistic abilities, which fact means the drawing does not have to be nice, but it is about the idea. Please sign each picture and make a short description what the thing presented in it could work for. You have 30 minutes for the task.”</p>
<b>Given 16 elements in four sets</b>	
<b>Scoring</b>	<p>Assessing the test takes place on three scales; A, B and C.</p> <p><b>Scale A</b> Scale A measures the number of pictures drawn in accordance with the requirements of test. All the drawings count, except for; (1) Drawings that are composed of more than 16 elements (NB; unless there exists justified suspicion that the extra element was added through inattention, and eliminating it does not significantly change the drawing itself; (2) Where not signed, meaning it is not known what the picture represents; (3) portray completely imitative things or ideas for example, a drawing portraying a table, signed as “a table”.</p> <p><b>Scale B</b> Scale b measures transformative abilities as well as elaboration and extent of drawing visualization and productivity. The results within the B scale are calculated in the following way:</p> $B = \sum \frac{(L_{el.} + L_{st.})}{N}$ <p>B= result in the B scale  <math>L_{el.}</math> =number of elements used in a single drawing  <math>L_{st.}</math> =number of sets used in a single drawing  N=number of qualified drawings</p> <p>Hence, in the scale B the raw result is calculated by summing up the number of sets and the number of elements used in order to create a single drawing. Then the partial sums obtained for each drawing are added up, and divided by the number of drawings. Therefore, the result in the B scale may fall between 2 and 20 points for each drawing. Two points are assigned to the drawing created with the use of a single element (1element + 1set = 2points) , and twenty points are given to a drawing composed of all elements (16elements + 4sets = 20points).</p> <p><b>Scale C</b> This scale is assessing the novelty of created works. As opposed to the previous two scales, it is to a certain context a subjective scale. The scores are as follows (1-low, 2-Medium, 3-High).</p>

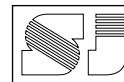


Table 6 table showing the Visual Flexibility Test criteria (Source: Researcher according to theoretical survey)

This section consists from 5 images each containing more than one organization. The assessment in this section is based on the analysis of the answers. This section measures the visual impression of images (5 minutes)



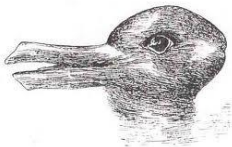


<p><b>Verbal Directions</b> "Write down what you see in the following figures"</p> <p><b>Figure 1</b></p>  <p><b>Scoring</b> A frog (1 point), A horse (1 point). Any other organization seen by the student, will add 1 point to another scoring level, the bonus level.</p>	<p><b>Figure 4</b></p>  <p><b>Scoring</b> An old man ( 1 point), A man on a horse (1 point) Any other organization seen by the student, will add 1 point to another scoring level, the bonus level.</p>
<p><b>Figure 2</b></p>  <p><b>Scoring</b> A rabbit ( 1 point), A duck ( 1 point). Any other organization seen by the student, will add 1 point to another scoring level, the bonus level.</p>	<p><b>Figure 5</b></p>  <p><b>Scoring</b> A man (1 point), A lady ( 1 point).</p>
<p><b>Figure 3</b></p>  <p><b>Scoring</b> A young lady ( 1 point), An old lady ( 1 point). Any other organization seen by the student, will add 1 point to another scoring level, the bonus level.</p>	

Table 7 The Visual drawing test (Source: Researcher according to theoretical survey)

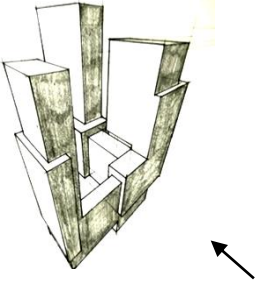
<b>Verbal Directions</b>	<p>"In this section you are given a perspective of a object, you are asked to draw the view as it is seen from the arrow." <i>This section aims for assessing the visualization of the figure as well as the drawing capacities of the student. (15 minutes)</i></p>
<b>Number of figures</b>	1 figure
<b>Figure</b>	
<b>Scoring</b>	<p>The drawing is to be scored according to;</p> <ul style="list-style-type: none"> <li>- Drawing a dimensional view or drawing a perspective. (2 points)</li> <li>- Shape, the visualization of object in general. (3 points)</li> <li>- Proportion and scale, the visual judgment and ability to estimate the dimensional relationships. (2 points)</li> <li>- Figure ground relations. (1 point)</li> <li>- Depths, the light and shadow as well as overlapping techniques. (1 Point)</li> <li>- Cleanness of drawing implying confidence during drawing. (1 Point)</li> </ul>

Table 8 Showing scoring and criteria for Drawing from imagination according to measurement of drawing (Source: Researcher according to theoretical survey)

<b>Verbal Directions</b>	<p>"In this last section is asking you are asked to draw a sketch of one of their last design projects." (15 minutes)</p>
<b>Figure</b>	<p>The student shall draw on one A4 size paper.</p>
<b>Scoring</b>	<p>Here is the student tested on his/her drawing skills, long term memory and design imagination.</p> <ul style="list-style-type: none"> <li>- Message coming through (3 points)</li> <li>- Complexity in drawing (2 point)</li> <li>- Size of drawing (1 point)</li> <li>- Density in drawing (1 point)</li> <li>- View of the drawing (1point)</li> <li>- Techniques in drawing (1 point)</li> <li>- Cleanness of drawing (1 point)</li> </ul>



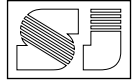
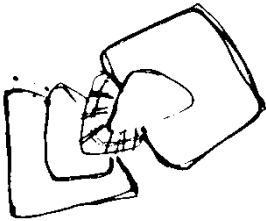
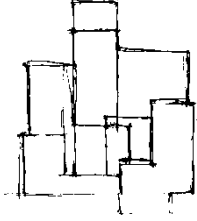
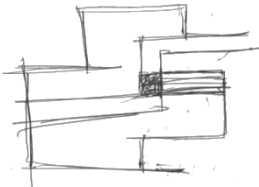
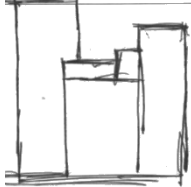

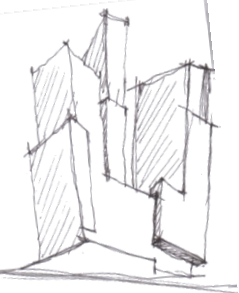




Table 9 Showing a few results of the student test for the last two drawing categories (Source: Imagination tests)

	Drawing from Imagination	Visualized drawing
1		
	<p>The above two drawings show results for a right brained student preferring to use conventional drawing tools for 85% during design being very familiar with ACAD and not familiar with other digital tools, with the following data: Complex mental image score: 5/10, Simple menatl image score 4/10, TCI score (A=3, B=2, C=0), Image intreprtation score A=5 while the B=0.</p>	
2		
	<p>The above two drawings show results for also a left brained student who uses conventional drawing tools for 70% of the design process and is highly familiar with ACAD, 3DMAX as well as SketchUP. And scores the following: Complex mental image score: 2/10, Simple menatl image score 3/10, TCI score (A=0, B=0, C=0), Image intreprtation score A=0 while the B=0.</p>	
3		
	<p>Above and left drawing show the drawings of a right brained student using conventional drawing tools for 40% of the design process and has medium familiarity with ACAD as well as SketchUP. This student scores as follows: Complex mental image score: 8/10, Simple menatl image score 8/10, TCI score (A=1, B=6, C=1), Image intreprtation score A=6 while the B=2.</p>	
4		
	<p>Above and right of a right brained student using conventional drawing tools for 30% of the design process as having only medium familiarity with ArchiCAD. This student has the following scores; Complex mental image score: 10/10, Simple menatl image score 6/10, TCI score (A=2, B=10, C=2), Image intreprtation score A=9 while the B=0.</p>	

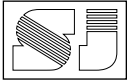


Table 10 Showing the measurement criteria for imagination and drawing  
(Source: Researcher according to theoretical survey)

Basic Element	Sub Element	Indicator	Characteristics	
Measurements of imagination (Imagination Criteria)	Types of Imagination	Spontaneous Imagination	Effortlessness Surprise Instantaneity Initiation	(Right brain function)
		Controlled Imagination	Guidance Termination	(left brain function)
	Levels of imagination	Reproductive imagination	Effectiveness	Individual often completes tasks by focusing on effective ideas
			Transformation	Individual thinks flexibly and is able to transfer ideas to multiple fields of tasks
			Crystallization	Individual is good at expressing abstract ideas by using concrete examples
			Elaboration	Individual improves his thoughts by focusing on formalizing ideas
		Creative Imagination	Exploration	Individual likes to explore the unknown
			Intuition	Individual often comes up with new ideas through intuition
			Sensibility	Individual often helps himself to imagine through feelings
			Productivity	Individual has constantly new ideas about the design
Novelty	Individual often has uncommon ideas compared to others			
Visual imagery	Visualization	Envisioning through minds' eye Visual impression flexibility in seeing different organizations		
Measurements of drawing (Drawing Criteria)	Imagination related aspects	Effortless object imagination	Message coming through Complexity in drawing Size of drawing Density in drawing View of the drawing Cleanness of drawing	
	Drawing skill related aspects	Effortless drawing capability	Message coming through Complexity in drawing Size of drawing Density in drawing Techniques in drawing Cleanness of drawing	

