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## **An Investigation on the Effect of Drawing Techniques towards Students' Performance and Perception in Architectural Education**

**Timuçin HARPUTLUGİL<sup>1</sup>, Sıla ÇANKAYA TOPAK<sup>2</sup>, H. Nur ÖZKAN ÖZTÜRK<sup>3</sup>**

*<sup>1</sup>Assist. Prof. Dr. , Çankaya University, Faculty of Architecture, Department of Architecture, tharputlugil@cankaya.edu.tr*

*<sup>2</sup>Full Time Instructor , Çankaya University, Faculty of Architecture, Department of Architecture, silacankaya@cankaya.edu.tr*

*<sup>3</sup>Research Assistant , Çankaya University, Faculty of Architecture, Department of Architecture, nurozkan@cankaya.edu.tr*

### **ABSTRACT**

Emerging technologies allow digital production to be used within the initial stages of architectural design. The design process, in which drawing is the main tool, is affected with the rapid increase of digital production in the building sector and increasing awareness on digital drawing and production/fabrication is an undeniable fact of 21<sup>st</sup> century. In this context, the article investigates the status of hand (manual) and computer (digital) based drawings in architectural education; the students' perceptions and its effects on their performances. A case study -within the context of the Construction Systems II course given at the Architecture Department of Çankaya University-has been conducted to evaluate/quantify the students' perceptions in order to demonstrate the advantages and disadvantages of hand and computer based drawings. Positive correlations of the familiarity to the drawing tool with easy correction of mistakes and relation of familiarity to the drawing tool with time management is observed. Based on the research; there is not a significant difference between hand based or computer based tools regarding spent time for the work in student practices; however, the process regarding revision, correction, or composition of drawing decreases time spent in computer aided drawing. Consequently it has been noticed that as the capability in drawing tool increased, the class performance of students increased too. The outcomes of the case study based on observations, evaluation, questionnaires and analysis covering an academic term, are discussed in detail within the scope of the article.

**Keywords:** Architectural Education, Computer Aided Architectural Design, Computer Based Design, Hand Based Drawing



## **1.INTRODUCTION**

Design action is the basic activity of architecture (Simon, 1969) and thus constitutes the spine of architectural education. Architectural design differs from many other design disciplines by its content, scope and context, which as a result makes the educational process intense and complicated. Through the historical perspective, it can be seen that jury-based evaluation systems in the tradition of academia (Alagbe et al., 2015), which has been cultivated with master-apprentice relation since the 18th century, has now transitioned to different approaches in different schools. Although, all the architecture schools carry out different approaches and programs, drawing is still being used as the main tool of design.

Rapid integration of design and production processes together with expeditious developing technology affected not only building technology, but also architecture education and training. In the practice and education of architecture, while drawings were done by hand until the last quarter of the 20th century, computer drawing have seem to become widespread with increasing popularity stemming back to the 80's. The rapid development of computer technology, along with the diversification of software for design, the reduction of the physical workload and the shortening of the process of drawing are possible reasons listed for the increased use of computer technology. In correlation with the increased use of computer technologies in the professional field of architecture, training in architecture has also begun to lean more towards this approach, resulting in the increase of computer use compared to hand for drawing. One of the most frequently discussed and sought-after topics in contemporary architecture education is the discussion of whether drawing should be done by hand or with the help of computer technology. The article intends to contribute answers to this question with outcomes of a case study conducted within the Construction Systems II course of Architecture Department of Çankaya University, spring of 2017.

Within the research, it was noticed that the terminology used regarding the topic varies broadly in the literature review. In the scope of the article, the study describes the hand drawing (analog / manual / hand) made at the desk physically and computer drawing (digital/cad) as the drawing made with help of computer technologies.

## **2.LITERATURE REVIEW**

There are many publications related to the importance of drawing in the field of architectural design. Schön (1991) defines architectural drawing as the language of design, while Akın (1986) paying attention to the importance of drawing in the design process, defines drawing methods as paths to convey the architect's design. Emphasizing



that hand is the most important tool of drawing, Pallasmaa (2009) argues that the hand is bridge between the mind and the building. In addition, he believes that architecture is a production of a thinking hand which is effective through design stages. However, Güney (2015) notes that the use of computers allows designers to spend less time and energy in their design and drawing processes, besides computers create different opportunities for designers.

It is seen that the approaches of architectural schools differ in this sense. It is possible to classify schools based on their policies regarding drawing techniques such as: the schools i) only allow hand-drawing, ii) allow hand and computer together, iii) allow only computer for drawing (Kara, 2015). In this context, particularly in Turkey, many schools require students to make drawings by hand during their freshman terms, followed by orientation drawings with computers during their sophomore and junior year, and finally encourage computer drawings to be made in their senior year (Güney, 2015).

In addition to the training and practice of hand drawing techniques over the course of years, Pektaş (2007), in his article which discusses how computer-aided architectural drawing should be taught, refers to the prospective contents defined as forward-looking requirements of the digital design theorem. It is also possible to find a significant number of publications in which hand and computer drawings are compared rigorously. Tayfun et al. (2010) made a comparative analysis of hand and computer drawings in eight main subjects namely i) expressing and designing space considering its requirements, ii) precision and quality, iii) photo realistic presentations, iv) easiness of revision, v) allowance for new design proposals, vi) easiness for achieving, vii) adaptability for distant learning, viii) satisfaction of tutors and students, based on a case study they did in their department of architecture. Basa and Şenyapılı(2006) investigates the hand, the computer and mixed use of them with a questionnaire, followed by a jury evaluation as a case study conducted in an interior architecture department. They convey that it is difficult to change the traditional viewpoint of the academy against computer drawings in interior architecture departments and point out that hand drawing is crucial for interior architecture departments. Depending on a research in department of interior architecture, Pektaş and Erkip (2006) point out, instructors tend to be more responsive to hand drawing more than students based on the way they were trained. In a study conducted by Çil and Pakdil (2007) in the Department of Architecture at Middle East Technical University, they determined that faculty members perceived computer as a threat to the development of students' perception and presentation skills.

Developments in computer technology is proceeding at a dizzying pace, consequently new technologies and techniques are introduced. Muscogiuri (2016) mentions about



software development for integrating hand and computer drawings. Following the Computer Aided Drawing (CAD) to Computer Aided Architectural Design (CAAD) transformation, CAM (Computer Aided Manufacturing) and BIM (Building Information Modelling) systems are introduced for further integration of design, and production processes based on a common digital table with cooperation of actors in the design. In this context, within a study pointing out the importance of the integration of design and manufacturing processes of Ambrose (2012) suggests that BIM can act as a special catalyst for critical analysis of how the design process is thought and taught in.

This study does intend neither to prove the superiority of a drawing technique over the other nor to be a part of these discussions. The paper seeks to define the perceptions of students and aims to identify the reflection of the changes in the students' performances due to growing interest in hand drawing to computer drawing over the years.

### **3.MATERIAL & METHOD**

#### **3.1.The Context and Content of the Study**

This study examines the effects of production techniques with analog or digital drawing on the students' performance and perception, depending on the developing technology in architectural education. The relation of studied drawing techniques is discussed with observation, research, investigation and evaluation throughout the term in applied construction systems course. The study is conducted in 2016-2017 spring semester in Department of Architecture, Çankaya University within the course of Construction Systems II, which is a continuation of the first construction technologies course. The course of Construction Systems II is also instructed by the authors of this study. Within a sample of registered students of the course, it examines the effects of utilization of analog and digital drawing tools on the student performance in terms of both their perception and tangible production skills. In order to register for this course, students need to be successful in the courses of technical drawing, architectural technical drawing and construction systems I as part of the curriculum. Taking into consideration that during the semester students are enrolled in Construction Systems II as well as a computer-aided design course, which allows for them to use computer systems more efficiently. The computer-aided design course provides students not only with the fundamental techniques used in architectural technical drawing but also with computer usage experience.

Study consists of the succession of a couple of steps. In the first step, it is meant to evaluate the perception of the students towards this subject. In that context, a questionnaire including five-point Likert scale, which consists of multiple choice



questions, is conducted to evaluate the socio-demographic distribution amongst the students enrolled in the construction systems studio and the effects of hand and computer drawing (Appendix). The enrolled 88 students are given the flexibility of making drawings by hand or by computer during studio based on personal preference. Within this context 51 students prefer to make drawing by computer, whereas 37 students prefer to make drawing by hand. The 72 participants were chosen from the student group with the nonprobability volunteer sampling method. Whilst 32 students chose to draw by hand, 40 students preferred to draw by computer. The study was evaluated by comparing these two groups. The results of questionnaire in this study was analyzed with statistical analytic program SPSS v.25 (IBM Corporation, 2017). Besides the evaluation of perception of students, this study aims not only to present the positive and negative characteristics of hand and computer based drawings but also to explore whether there is a distinction between students' performance grades in terms of these negative and positive characteristics. With respect to the results of questionnaire, the classwork of students was discussed comparatively in terms of the evaluation of hand and digital drawing ability of students. This study aims to examine the perception of students and their reason behind the preference of drawing technique, by the comparison between results of the questionnaire and the produced works of students throughout the semester.

## **4. RESULTS**

### **4.1. Questionnaire**

The conducted questionnaire aims to evaluate the characteristics of a preferred drawing technique and its contribution to the student performance. The questionnaire is composed of five sections. To reflect the general profile of the participants, socio-demographic characteristics of the students are researched in the first section. In the second section, the determination of drawing technique of the student in the course is aimed. Whilst there are the questions which inquiries about the characteristics of the drawing technique in the first parts of the third and fourth section, second parts of related sections include the questions investigating the relation of drawing technique with student performance and model making process. Last section includes the self-evaluation of the student's ability in drawing tool and individual course performance.

First of all, when the socio-demographic characteristics of the students are analyzed, it was observed that the majority of students was composed of female students (%69.9). It was seen that %60.3 of the students were recorded as graduates of Anatolian High Schools. For the condition of accommodation, it was observed that the majority of the



students were living with their parents (%67.1). Table 1 includes the detailed information about demographic information.

Table 1. The socio-demographic characteristics of students

<b>Socio-demographic results</b>	<b>Frequency (n)</b>	<b>Percentage (%)</b>
<b>Gender (n=73)</b>		
Male	22	30.1
Female	51	69.9
<b>Age (n=73)</b>		
19	5	6.8
20	12	16.4
21	23	31.5
Other	33	45.2
<b>Grade Level (n=71)</b>		
2	51	69.9
3	16	21.9
4	4	5.5
<b>Semester (n=72)</b>		
2	3	4.1
4	45	61.6
5	12	16.4
6	7	9.6
7	1	1.4
8	4	5.5
<b>Graduation School (n=73)</b>		
High School	8	11
Science High School	2	2.7
Anatolian High School	44	60.3
Teacher High School	6	8.2
Technical High School	1	1.4
Industrial School	1	1.4
Basic High School	1	1.4
Private High School	8	11



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Other	2	2.7
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Grade Point Average (GPA) (n=73)

3.5-3	11	15.1
3-2.5	29	39.7
2.5-2	25	34.2
2-1.5	8	11

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The Condition of Accommodation (n=73)

Home > With parents	49	67.1
Home > With home mate	13	17.8
Dorm > State Dorm	1	1.4
Dorm > Private Dorm	8	11
Other	2	2.7

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Number of Enrollment (n=73)

1	71	97.3
2	2	2.7

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(\*) Undesirable responses are not shown in the result table.

The third and fourth section of the questionnaire includes the questions about competency in drawing, time management, performance and drawing conditions. These questions were prepared in a five-point Likert scale, and recoded to three-point scale to convey the results easily. In the third and fourth section, Independent samples t-test was run at 95% significance level, and the characteristics of the drawing techniques used by the students are compared in terms of their mean values ( $\mu$ ). Student approaches which are compared by mean values were also supported by frequency tables in order to better reflect the results. In addition to that, the relation between questions were analyzed and they were measured in an ordinal level. Spearman rho coefficient ( $r_s$ ) is used to evaluate the correlation of ordinal variables with each other and the dependency between the questions (Argyrous, 2011). Spearman's rho value ranges from "-1" to "+1" and the values higher than 0.3 indicates a significant correlation. Whether the value is positive or negative it gives information about the direction of correlation. Therefore, Spearman's





rho is defined as an evaluation test in order to evaluate the relation between questions with each other.

According to the results of frequency tables, the different or common evaluations includes the reasons behind the preferences of drawing technique of the students. Accordingly, students have both hand and computer drawing tools and know how to draw with both. It is seen that the habit of drawing technique is the main forefront reason for this preference (Table 2).

Table 2. Frequency table analysis

Questions	Frequency Table					
	Hand			Computer		
	+1	0	-1	+1	0	-1
I am used to drawing by hand/computer	%84.4	%12.5	%3.1	%95	%5	%0
I only know how to draw by hand/computer	%34.4	%9.4	%56.2	%2.5	%2.5	%95
I only have tools for hand drawing /computer drawing	%0	%6.2	%93.8	%5	%2.5	%92.5

(\* ) (+1) Agree, (0) Neutral and (-1) Disagree

According to the results of Independent samples t-test, students evaluated drawing techniques with significant differences in the questions with related topics as time management, drawing conditions, ease of archiving. In the light of this bit of information, the evaluation of questions which is given in table differed between both drawing techniques (Table 3). According to table, it can be interpreted that the reasons to prefer computer drawing are the effect on time efficiency, suitability of the studio conditions with computer drawing, ease of filing, easier recognition of mistakes, faster correction of mistakes and easier mobility with computer. In addition, hand drawing was evaluated as negative in these mentioned reasons.

Table 3. Independent samples t-test and frequency table analysis

Questions	Frequency Table					
	Hand			Computer		
	+1	0	-1	+1	0	-1
It helps me to use time efficiently	%0	%15.6	%84.4	%95	%5	%0



( $p$ value = 0.0001, $\alpha < 0.05$ )						
Studio conditions are more suitable for hand drawing/ computer drawing ( $p$ value = 0.0001, $\alpha < 0.05$ )	%6.3	%6.2	%87.5	%75	%22.5	%2.5
I file the hand-drawn / computer-drawn works more easily ( $p$ value = 0.0001, $\alpha < 0.05$ )	%18.8	%12.5	%68.8	%95	%5	%0
I notice my mistakes more easily with hand drawing /computer drawing ( $p$ value = 0.002, $\alpha < 0.05$ )	%50	%18.8	%31.2	%80	%15	%5
I correct my mistakes faster by hand drawing/ computer drawing. ( $p$ value = 0.0001, $\alpha < 0.05$ )	%6.2	%9.4	%84.4	%97.5	%2.5	%0
I study more mobile by hand drawing/computer drawing ( $p$ value = 0.0001, $\alpha < 0.05$ )	%0	%9.4	%90.6	%90	%7.5	%2.5

(\*) (+1) Agree, (0) Neutral and (-1) Disagree

When asked the effect of the drawing techniques on course performance, 40.6% of the students that drew by hand evaluated negatively, while the majority of the students drawing with computer were evaluated as positive (92.5%). In addition to that, the effect of drawing technique of the students on model making process is investigated and according to the results, students who draw by hand evaluated contribution of the hand drawing on model making process negative (%63.6), students drawing with computer evaluated it positive (%80). In last part of questionnaire, it was asked to evaluate competency in drawing and course performance. Accordingly, majority of students drawing with computer (%89.7) and students drawing by hand (%54.8) felt very competent by the drawing technique they used. When asked about the course performance evaluation, it is seen that most of the students drawing with computer found their performance successful (%74.4) whereas students who draw by hand showed an unstable attitude (%48.4) as the majority. In this sense, according to the student perception, drawing with computer was preferred in many aspects compared to hand



drawing and it is thought that these aspects contribute more to the course. The relation of questions with each other brings about important results in terms of understanding the association of many factors. First of all, when the results of the students who preferred drawing by hand was investigated, it was observed that there is a significant positive correlation between the questions with related topics as ease of archiving and learning better with hand drawing ( $r_s = +0.629$ ,  $p = 0.0001$ ,  $n = 32$ ) ( $r_s =$  Spearman rho coefficient,  $p =$  the exact probability,  $n =$  number of participants) and between ease of archiving and easier recognition of mistakes ( $r_s = +0.487$ ,  $p = 0.005$ ,  $n = 32$ ). It can be interpreted that the increase in ease of archiving of the produced drawings results in easier recognition of mistakes and the students learn better. Another important correlation was found between the questions related topics as easier recognition of mistakes and learning better ( $r_s = +0.475$ ,  $p = 0.006$ ,  $n = 32$ ). Results of the study showed that easier recognition of mistakes promotes hand drawing as a better learning technique according to the perspective of students.

First part of the third section includes the characteristics of drawing technique whereas the second part of it investigates the contribution of hand drawing to course performance and model making process. When the relation between these two part was analyzed with each other, it was observed that there is a correlation between contribution of hand drawing to the model making process and easier recognition of mistakes ( $r_s = +0.380$ ,  $p = 0.0032$ ,  $n = 32$ ). This situation can be interpreted as that the increase in the control of mistakes in drawing leads to increase in the control of model making.

In the fifth section, when compared the questions of course performance and competency in drawing, it was observed that there is a positive correlation between the competency in drawing technique and course performance ( $r_s = +0.446$ ,  $p = 0.012$ ,  $n = 31$ ). The students thought that the course performance improves as the students evaluate themselves competent in the related drawing.

Secondly, when analyzed the results of students drawing with computer, it was observed that there is a significant positive correlation between the habit of e drawing and time management ( $r_s = +0.474$ ,  $p = 0.002$ ,  $n = 40$ ). According to the results, it was seen that the habit of drawing with computer helps student to use time efficiently. In addition to that, a positive association between the habit of drawing technique and faster correction of mistakes was found ( $r_s = +0.698$ ,  $p = 0.0001$ ,  $n = 40$ ). Besides, there was a positive correlation between faster correction of mistakes and time efficiency ( $r_s = +0.698$ ,  $p = 0.0001$ ,  $n = 40$ ) and between faster correction of mistakes and easier mobility with computer ( $r_s = +0.467$ ,  $p = 0.002$ ,  $n = 40$ ). In that sense, it was seen that the student who



corrects mistakes faster uses time more effectively and the fact that the student who draws independently from the provided space with the usage of computer, contribute to the quick correction of mistakes. Last important connection in the third section was observed between learning better with computer and easier recognition of mistakes ( $r_s = +0.638$ ,  $p = 0.0001$ ,  $n = 40$ ). Therefore, it was interpreted that easier recognition of mistakes contributes the better understanding of drawing.

When analyzed the relation between characteristics of drawing techniques, course performance and model making process in the third section, it was observed that there is a positive correlation between habit of drawing technique, usage of time efficiently, faster correction of mistakes and drawing performance. According to the results, it can be said that as the habit of drawing with computer increases, the performance of lesson improves positively ( $r_s = +0.806$ ,  $p = 0.0001$ ,  $n = 40$ ). In addition to that, it was observed that effective use of time affects course performance positively ( $r_s = +0.370$ ,  $p = 0.0019$ ,  $n = 40$ ), and faster correction of mistakes is also effective in improving the course performance of the student ( $r_s = +0.562$ ,  $p = 0.0001$ ,  $n = 40$ ). Moreover, it was found that there is a positive correlation between effective use of time, faster correction of mistakes and model making process. In that sense, it can be deduced that the increase in effective use of time affects the model making process positively ( $r_s = +0.459$ ,  $p = 0.0003$ ,  $n = 40$ ) and as correction of mistakes becomes faster, model making process improves ( $r_s = +0.320$ ,  $p = 0.044$ ,  $n = 40$ ).

Between the fifth section and third section, three associations were found. It was observed that there is a positive correlation between the competency in drawing and the habit of drawing technique, and between efficient usage of time and faster correction of mistakes. When interpreted these relations, as the habit of drawing technique increases, the competency in drawing increases ( $r_s = +0.688$ ,  $p = 0.0001$ ,  $n = 39$ ). When thought the contribution of drawing with computer to efficient usage of time ( $r_s = +0.688$ ,  $p = 0.0001$ ,  $n = 39$ ) and faster correction of mistakes ( $r_s = +0.480$ ,  $p = 0.002$ ,  $n = 39$ ), it was observed that students feel more competent in computer drawing.

Though the relation between course performance and model making process was analyzed, it was observed that there is a positive correlation between course performance and the model making process; and between course performance and the competency in drawing. Therefore, as the competency in drawing increases, the student's course performance increases ( $r_s = +0.537$ ,  $p = 0.0001$ ,  $n = 39$ ). Likewise, according to the student, as competency in drawing increases, model making performance also increases ( $r_s = +0.456$ ,  $p = 0.004$ ,  $n = 39$ ).



## **4.2. Evaluation of Hand Drawing and Computer Based Drawing Techniques on Examples**

Drawing practice that was made by the students throughout the semester is evaluated by course conductors and appearing positive and negative conditions were described considering survey results.

### ***4.2.1. Evaluation of Hand Based Drawing***

Within the scope of Construction Systems II course, each student was asked to present a circulation and roof detailing in two separate example with production drawings in a particular sheet organization considering both the theoretical and practical knowledge given in the semester. Evaluation of the progress was done regarding circulation, roof structure and construction details that were produced in lecture hours.

Basic failures on hand based drawing type were mainly improper line weight, crosshatch, line weight consistency and line hierarchy depending on drawing technique, with lack of technical drawing knowledge, incapability in the transfer of three dimensional design knowledge into two dimensional plane, and inefficiency in the continuation of building elements depending on construction drawing knowledge. Besides mentioned basic failures, there were several other observed inadequacies related with the in class performance of students; line quality that went bad in the following periods of class hours, abandoning line hierarchy, interruption in crosshatches, lack of expression in technical information, such as the name of floor level, room name, spot elevation, dimensions, and material type. Additionally, lack of project detailing depending on drawing density, and difficulties in expression of plans, sections, and details that are in different scales are other deficiencies that were faced during class hours (Figure 1).

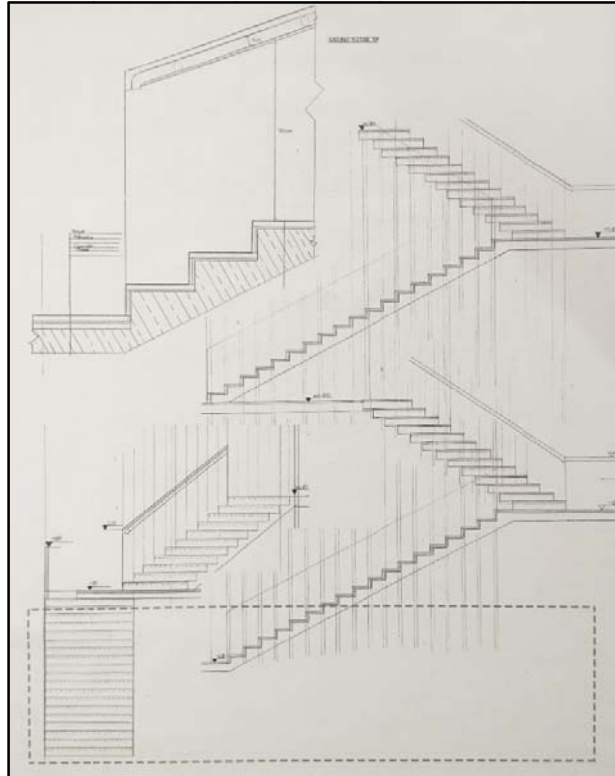


Figure 1. Student work I (Deficiencies in production in repetitive drawings).

In hand drawing practice, it is observed that the students had difficulties in the exercises that depend on multiple point transfer, such as circular stairs. Constriction in utilization of drawing tools such as French curve and compass besides t square, ruler, and miter ruler also drew notice (Figure 2). Besides lack of knowledge and experience, threedimensional perception problem while making a drawing in two dimensional plane had also attracted attention.

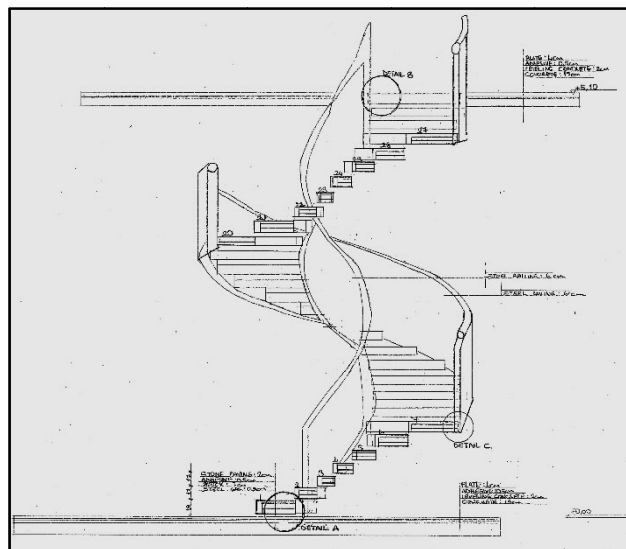


Figure 2. Student work II (Defects that are related with technical drawing knowledge).

Besides all of these inadequacies, problems in dimensioning and detailing also appears with respect to other mentioned deficiencies (Figure 3).

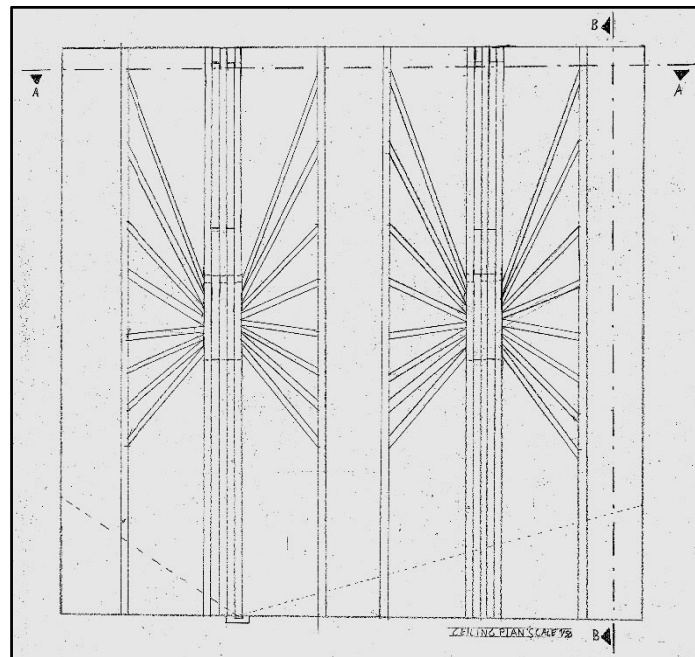


Figure 3. Student work III (Insufficiencies in detailing).

Regarding the presentation of hand based drawing, it is also observed that the students faced with positioning and scale problems (Figure 4).

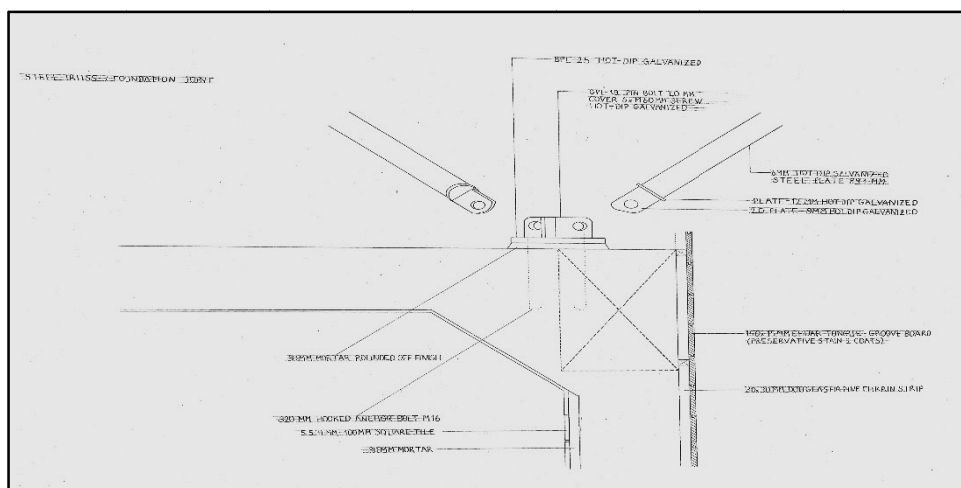


Figure 4. Student work IV (Problems in scale and aspect ratio of drawings).

Pros of hand based drawing can be listed as; control over the whole of a drawing, scale and relatively proportion related subjects and reflection of them on drawing, and attention on possible errors during design stage. Furthermore, possible mistakes during drawing stage can be easily recognizable, unlikely to computer drawing case, no print is

necessary. Additionally, spontaneous capability of model making to drawing stage is noted as a positive value.

#### 4.2.2. Evaluation of Computer Based Drawing

Within the scope of the group that consists completely of CAD users, one of the most important deficiencies is lack of experience. Relatively, the problems originating from off scale perspective due to the limitation of a screen is observed in students' works. With the increase in the size of the project, the detailing and transfer of detail to a whole becomes difficult to manage, which in return leads to an overall loss of control throughout the project. Additionally, students had mutual problems in common sheets that have drawings that are in various type of scale regarding text height, dimensioning, and line weight adjustment.

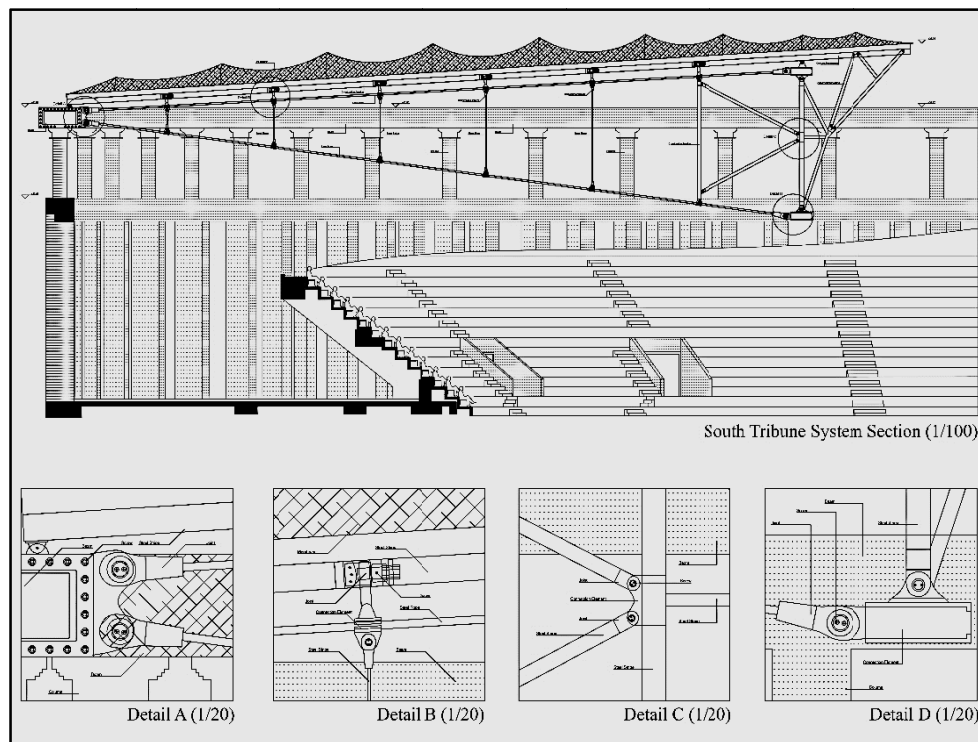


Figure 5. Student work V (Inconsistencies in text heights, mistakes in line weight, and lack of dimensions).

The other problem about the capability of utilized CAD software is the plot and print of drawings without necessary technical expressions and scale. In this context, problems related with improper line weight, and relative colorful print-outs that do not make any sense in technical terms, and inconsistencies in text heights in plotted drawings are the most common problems that were observed among students (Figure 6).



One of the advantages of computer based drawing, compared with hand drawing, is the ease in reproduction or making a copy of the relevant drawing. For instance, regarding the cross section of a particular stair that continues on several floors, adaptation of higher floors is quite easy after the production of typical section of one floor, and takes less time comparing with hand drawing of the same section. In Figure 7, mistakes regarding the connection detail, crosshatches, line weights, text heights and dimensions in a section drawing of the structure of building with landing can easily be observed. In connection with these, solution process of mentioned problems regarding the drawing is quite slower than hand based drawing.

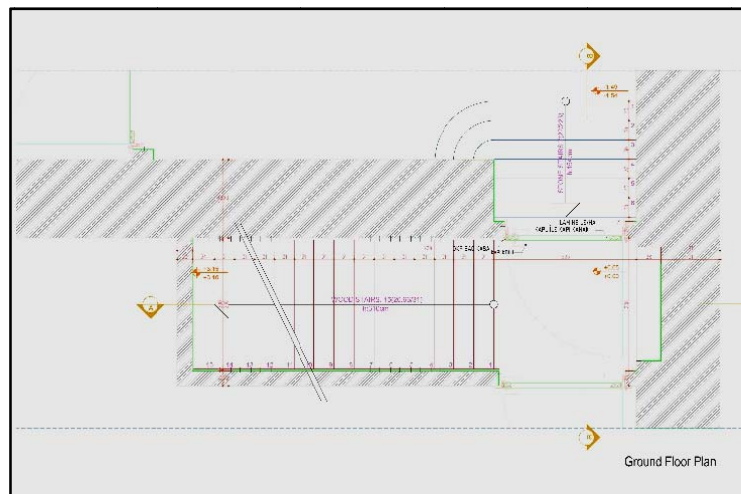


Figure 6. Student work VI.

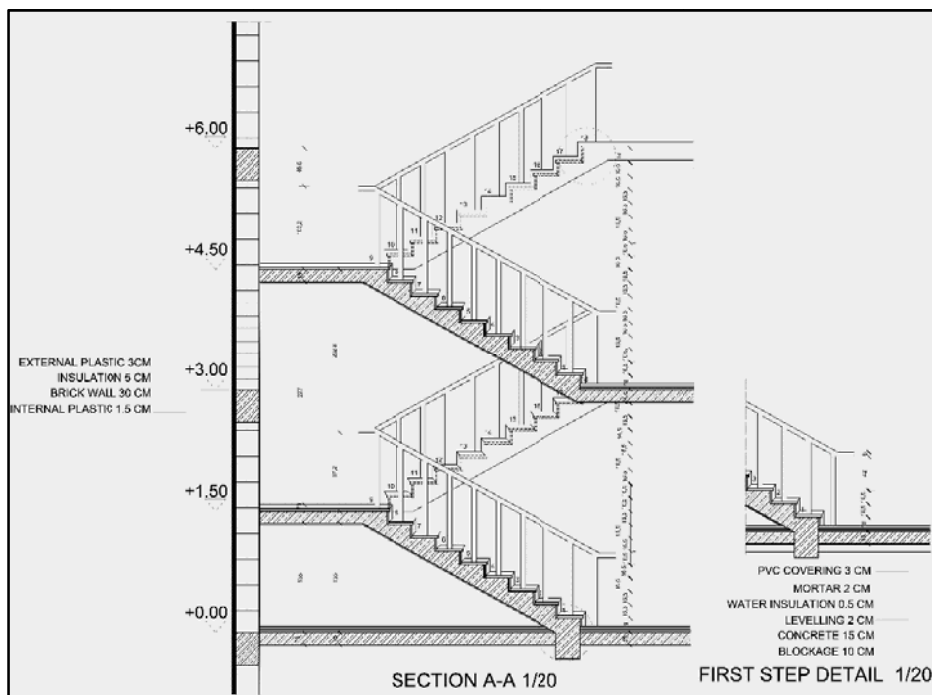


Figure 7. Student work VII.

Another positive aspect of computer based drawing is convenience in understanding the relation between two and three dimensional knowledge. Students comprehend three dimensional building with the help of 3D modeling availability offered in a digital environment and recognize the mistakes in a well-enhanced way with the help of computer based drawing tools (Figure 8).

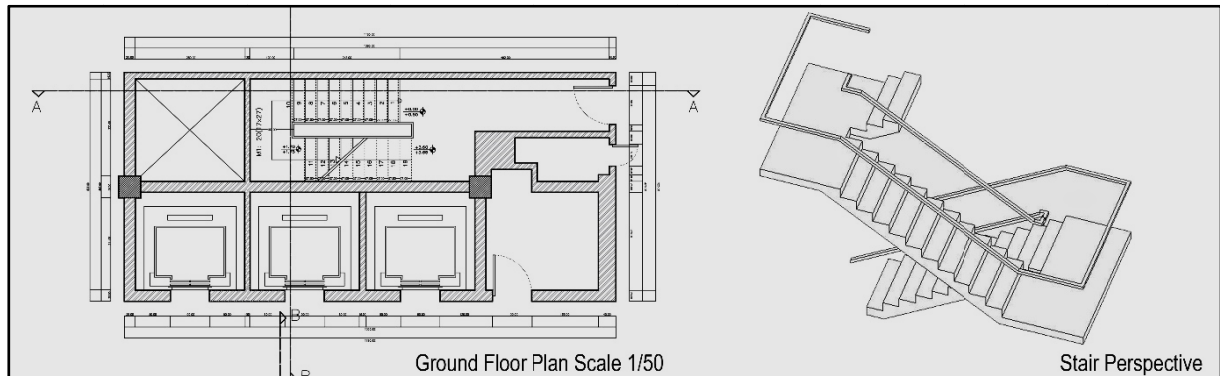


Figure 8. Student work VIII (Relationship between 2D and 3D drawing).

The ability of working with a computer in various places compared to the space limitation of hand based drawing, gives way to the efficient use of time for the production of a drawing, certainly an advantage for the correction of mistakes at a faster pace. Moreover, there is a significant amount of gain with the storage of drawings in a digital environment, in comparison to the actual storage of hardcopies, with the return of better capability in sheet organization and final product preparation.

## 5. DISCUSSION

In this part, discussion of interview results with respect to the criticism on in-class drawings is directed. Main differences between hand based drawing and computer based drawing is related with the control over the drawn object. It is harder to keep control of drawing in computer based methods compared with hand based methods. The main difference is in the representational style of these two methods, typical interface of CAD based software are not similar with hand based drawing methods; correspondingly, it has its disadvantage in educational progress. Similarly, the notion of scale could be lost with the zoom in and out commands on screen. The observations are also consistent with interview results that shows drawing mistakes could be noticed more easily in hand based methods.

The results of the interview showed that competence in a drawing tool affects performance during the class in a technical course such as Construction Systems.



Furthermore, students increase their in-class performance when they sense they are competent with the drawing technique they use.

Regarding the second year architecture students whom the research was conducted on, it is observed that implementation of critics and revisions takes quite less time in computer based tools, considering that it takes nearly same time to draw on a specified subject utilizing hand based or computer based drawing methods. It can also be related with the interview results that show students that use computer in the drawing process think that they are successful in time management. With this observation, it can be said that there is an important positive correlation between drawing skills and time management according to interview results, and it also corresponds with existing conditions in class.

The requirement of a table with relevant drawing tools for the hand drawing method and the difficulty in carrying these tools, while with just a computer CAD based methods is adequate. Accordingly, it provides the flexibility of working independently from any place. Furthermore, storage is rather advantageous comparing with hand based drawing regarding digital archive of files, homework submissions, and sheet composition.

In the general sense, students raising awareness and interest in computational drawing are observed in the undergraduate education period. An explanation for this might be the demand of computational software skills in sector. Within the scope of this study, the reasons behind the interest in computer design are, the idea of drawing faster with computer; capability in the revision process; and drawing potential of independent place, time and numerous drawing tools with the computers that they have, depending on lecturers' observations and interview results. However, similar problems were repeatedly observed, such as line weights, text heights in drawings or dimensions, crosshatch scales, and line type scales in computer print outs. Additionally, lack of ability in finalization of the work and preparation for print out was also observed.

In their freshman and sophomore year education in department of architecture, students are asked to produce their drawings with hand based methods. This is the most determinant factor in the selection of hand based methods during the semester. Moreover, lack of experience in computational drawing is also observed, and eventually, they intended to select a method that they feel comfortable with. Nevertheless, three dimensional comprehension and relevant technical drawing mistakes can be challenging enough to be considered a significant problem. Furthermore, it is seen that they saw their mistakes easily.



## 6. CONCLUSION

Architecture is one of the fields that digital design and fabrication process has settled in, and it is affected critically with respect to the immense development in technology. In this context, this study observed, researched, examined, and evaluated the influence of drawing technique on the performance and perception of architecture students, who took the Construction Systems II course during the 2016-2017 spring semester at Çankaya University Department of Architecture. 88 students enrolled in the class, in which the authors of this article were the instructors of the course. The study consists of several steps, at first, the primary objective is the perception of the students that took the class, depending on observation. The results of the interview (Appendix) showed several points. The first is the main reason behind the utilization of hand based tools and that is its familiarity to the methods from freshman year, while computer based methods allows time efficiency, easy recognition of mistakes, fast revision in drawing, convenience in storage, flexible working capacity in many places, and suitability of classrooms rather hand based drawing. Furthermore,

- While the effect of drawing technique to model making process is considered negatively in hand based drawing, it is regarded positively in computer based drawing.
- Computer users were feeling more successful in this class compared to with others.
- An important positive correlation was noticed between the convenience in drawing storage, better learning capability, and easy recognition of mistakes in hand based drawing.
- There is a relation between learning better in hand based drawing, and easy recognition of mistakes in hand based drawing.
- The performance of students were increased related with the feeling of self-sufficiency in a drawing tool.
- There is a relationship between the contributions of hand based drawing to model making process.
- There is an important positive correlation between familiarity to the drawing tool and time management.
- There is a positive correlation between the familiarity to the drawing tool and easy correction of mistakes.
- There is a relation between learning computer based drawing tools and easy recognition of mistakes. In other words, as the capability in drawing tool increased, the class performance of students increased.



It can be declared that most of the interview results was consistent with each other. There are two main exercises studied in class throughout the semester, both interview and class performance was considered in the evaluation progress, and gave forth the following results.

Whether in hand based or computer based drawing, the capability in drawing techniques both increase drawing performance and provide an advantage for model making. There is not a significant difference between hand based or computer based tools regarding spent time for the work in student practices; however, the process regarding revision, correction, or composition of drawing decreases time spent in computer aided drawing. On the other hand, hand based drawing makes easier to recognize drawing mistakes because of the capability in seeing total drawing instead of partial view, which is a very restrictive aspect of computer based method regarding scale or proportion. Correspondingly, scale and proportion oriented mistakes appears rather more in computer based methods. Additionally, there is a common mistake in graphical adjustments such as line hierarchy, line weight, text height and dimension height, and print out submission in computer based method. In this regard, there is a separation between interview results and actual class performance in correlation with computer skills and easy recognition of mistakes. Computer based drawing provides the opportunity of flexible space usage during the drawing process whereas hand based method have certain space requirements; and in this regard, it can be said that the former makes the working process easier.

Consequently, increasing awareness on digital drawing and production/fabrication is an undeniable fact. It should be noted that the students who are the participants of this study are from Generation Y, and they were born into digital technology, and related tools, and this is a critical factor in the selection of drawing method. Moreover, capability in computer is also a significant topic to discuss. Gaining the skill and knowledge on a certain drawing tool increases both the in class performance and the self-confidence of students, and brings about success.

It is considered that with the increase in the integrity of flexible educational configuration, digital design and fabrication, the utilization of digital drawing will steadily increase. In this regard, the necessity of the revision in educational programs, change in existing educational spaces, and differentiation in assessment criteria in education are undeniable. Additionally, conducting a research on large control groups and determination of control groups with random sampling method for elimination of possible biases is recommended to further studies.



There is no possibility of an assessment depending solely on the results of this study. In this context, it is expected to the results of this study will contribute to further studies in this field.

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**APPENDIX**

**Dear Participant;**

**This questionnaire will be used in a research project which is conducted in Arch 234- Construction Systems II course in Department of Architecture, Çankaya University.**

**Your responses will be used only for academic purposes.**

**Thank you for your consideration.**

<b>COURSE TECHNIQUE EVALUATION QUESTIONNAIRE</b>	
<b>1</b>	<b>Please answer your demographic information.</b>
Gender	Male <input type="radio"/> Female <input type="radio"/>
Age	16 <input type="radio"/> 17 <input type="radio"/> 18 <input type="radio"/> 19 <input type="radio"/> 20 <input type="radio"/> 21 <input type="radio"/> Other <input type="radio"/>
Grade Level	1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/>
Semester	1 <input type="radio"/> 2 <input type="radio"/> 3 <input type="radio"/> 4 <input type="radio"/> 5 <input type="radio"/> 6 <input type="radio"/> 7 <input type="radio"/> 8 <input type="radio"/>
Graduation School	High School
	Science High School
	Anatolian High School
	Teacher High School
	Fine Arts High School
	Technical High School
	Industrial School
	Religious Vocational High School
	Basic High School
	Private High School
	Other ..... (Please write)

Grade Point	4-3,5	3,5-3	3-2,5	2,5-2	2-1,5	1,5-1	1-0,5	0,5-0
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Average (GPA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The Condition of Accommodation	Home > With parents							
	Home > With home mate							
	Dorm > State Dorm							
	Dorm > Private Dorm							
	Other .....(Please write)							
Number of Enrollment	1 <input type="radio"/>	2 <input type="radio"/>	3 <input type="radio"/>	4 <input type="radio"/>	4 and more <input type="radio"/>			

<b>2</b>	<b>Please mark the appropriate answer below.</b>
<b>In this course;</b>	
I am drawing with hand <b>(Please continue with third section)</b>	
I am drawing with computer <b>(Please continue with forth section)</b>	

<b>3.a</b>	<b>Please evaluate the reasons behind the preference of hand-drawing by marking the appropriate answer below.</b>				
	<b>Strongly Disagree (-2)</b>	<b>Disagree (-1)</b>	<b>Neutral (0)</b>	<b>Agree (+1)</b>	<b>Strongly Agree (+2)</b>
I am used to drawing by hand					
It helps me to use time efficiently					
I only know how to draw by hand					
I only have tools for hand drawing					
Studio conditions are more suitable for hand					



drawing					
I file the hand-drawn works more easily					
I learn better with hand drawing					
I notice my mistakes more easily with hand drawing					
I correct my mistakes faster by hand drawing					
I study more mobile by hand drawing					
<b>3.b</b>	<b>Please evaluate judgements below by marking the appropriate answer.</b>				
<b>How does hand drawing affect your performance in this course?</b>					
Extremely Positive					
Positive					
Neutral					
Negative					
Extremely Negative					
<b>How does hand drawing affect your model making process in this course?</b>					
Extremely Positive					
Positive					
Neutral					
Negative					
Extremely Negative					

<b>4.a.</b>	<b>Please evaluate <u>the reasons behind the preference of computer drawing</u> by marking the appropriate answer below.</b>				
	<b>Strongly Disagree (-2)</b>	<b>Disagree (-1)</b>	<b>Neutral (0)</b>	<b>Agree (+1)</b>	<b>Strongly Agree (+2)</b>
I am used to drawing by computer					



It helps me to use time efficiently					
I only know how to draw by computer					
I only have tools for computer drawing					
Studio conditions are more suitable for computer drawing					
I file the computer-drawn works more easily					
I learn better with computer drawing					
I notice my mistakes more easily with computer drawing					
I correct my mistakes faster by computer drawing					
I study more mobile by computer drawing					
<b>4.b</b>	<b>Please evaluate judgements below by marking the appropriate answer.</b>				
.					
<b>How does computer drawing affect your performance in this course?</b>					
Extremely Positive					
Positive					
Neutral					
Negative					
Extremely Negative					
<b>How does hand drawing affect your model making process in this course?</b>					
Extremely Positive					
Positive					
Neutral					
Negative					
Extremely Negative					



<b>5</b>	<b>Please evaluate judgements below by marking the appropriate answer.</b>	
<b>I am very competent on the drawing tool I used</b>		
Strongly Agree		
Agree		
Neutral		
Disagree		
Strongly Disagree		
<b>I find my performance very successful in this course</b>		
Strongly Agree		
Agree		
Neutral		
Disagree		
Strongly Disagree		