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An Optimum and Effective Drawing Teaching System in Engineering

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Abstract: In this study, the authors shall illustrate the difficulties, pros and cons of "Technical Drawing" courses in engineering curriculums. The authors also show the efficiency, effectiveness of students' grasping the engineering drawing concepts in depth. The authors have conducted a survey on students and their instructors for teaching the course. Whether the course should be taught with manual handling and then computerized or starting with computer aid and finishing the content of the course, the authors shall also go in detail of syllabus how the drawing rooms and aid tools will be. This part of study shall look into the ergonomics, safety and conditions of classrooms. Responses of 300 students will be shared in this presentation. Statistical analysis will detect the effects of different factors involved in the questionnaire.

Key words: CID (computer integrated drawing), efficiency.

1. Introduction

Evolution of technical drawing, historically, goes back to Sumerian for military use and classified as an important tool for military operations. Even Hammurabi era every building had some kinds of blue-prints showing the frame and walls of buildings. Technical drawing is known the least among engineering subjects because of the apprenticeship applied in the shops. Master taught the journey-men whatever is needed to produce an item or product/service. Industrial revolution necessitated the patterns of products before the final production, so that consumer and producer agree on dimensions and tolerances. Technical drawing teaching started in technical high-schools curriculum after 1900.

As today's globalize modern education in engineering, it is unwise to consider any computer system, least of all computer aided drafting or design, in isolation. Increasing emphasis on system integration, the boundaries between any engineering subsystems are becoming more and more blurred. Computer aided drafting is not just a matter for drawing office only. Computer aided design or (CAD) or computer integrated drafting (CID) influence all other areas and disciplines of any enterprise whether it is a production oriented or service systems concerned. CAD or CID is important tools in all branches of engineering. Because they patronize the desire and demand of customers, illustrating and illuminating specific properties and conditions mutually agreed on, upon the product or service for future delivery. It is in mechanical and production engineering, that CAD and CID explain the interesting varieties of applications. In this study, we shall describe the various elements they make up CAD or CID functions and explain how they fit together and interact with other parts of conveying (showing) and learning (grasping) systems; particularly, those that are connected with production or technical services demanded by consumers agreed on tolerances.

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2. Abbreviated Terms

Before going further, let us define those abbreviated terms (from three to six letter words) and explain clearly, so we may utilize them easily.

CAD: Computer Aided Design. This is the easiest of all. It means using computers interactively to help with the design process. This definition was in the 1960s. Today we shall define it as a set of tools for automating certain of the steps in the drafting/design process.

CID: Computer Integrated Drafting. Computer is utilized during drafting, obtaining the pattern of unit.

CAM: Computer Aided Manufacturing. The application of computers to the manufacturing process with some canned programs.

CAE: Computer Aided Engineering. The concept of automating all the steps involved in creating a product and enabling all engineering disciplines to share the data created by others.

CADCAM: Computer Aided Design and Manufacture. This was once used to describe computer aided design, drafting and manufacture using interactive workstations but is now often used to encompass the whole area of the computerization of manufacture.

CIM: Computer Integrated Manufacture, the concept of integrating all the functions of design and manufacture of a product into a unified system using computers.

CAPP: The Computer Assisted Passenger Prescreening System (often abbreviated (CAPPS) is a counter-terrorism system in place in an air travel industry. The United States Transportation Security Administration (TSA) maintains a watch list, pursuant to 49 USC § 114 (h)(2), of "Individuals known to pose, or suspected of posing, a risk of air piracy or terrorism or a threat to airline or passenger safety".

CAPM: Capital Asset Pricing Model, in finance, is used to determine a theoretically appropriate required rate of return of an asset, if that asset is to be added to an already well diversified portfolio, given that assets non-diversifiable risk.

MRP: Material Requirements Planning is a production planning and inventory control system used to manage manufacturing process.

MRP II: Manufacturing Resource Planning is defined by APICS as a method for the effective planning of all resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning in dollars, and has a simulation capability to answer "what-if" questions and extension of closed-loop MRP.

AI: Artificial Intelligence (AI) is the intelligence of machines and the branch of computer science that aims to create it.

CASE: Computer Aided Systems Engineering The concept of automating all the steps involved in creating a product and enabling all engineering disciplines to share the data created by others from the systems point of view.

MAP-TOP: Manufacturing Automation Protocol was developed by General Motors to combat the proliferation of incompatible communications standards used by suppliers of automation products such as programmable controllers. In 1986 the Boeing Corporation merged its Technical Office Protocol with the MAP standard, and the combined standard was referred to as "MAP/TOP". The standard was revised several times between the first issue in 1982 and MAP 3.0 in 1987, with significant technical changes that made interoperation between different revisions of the standard difficult.

TDD: Technical Drawing and Design. Design is the common denominator of engineering. It is the repeated/iterative process through which an engineer is able to optimally convert available resources into devices or systems that satisfy the consumer needs to which the design is addressed. Engineering schools, recognize that the engineer's discipline and skills are more fundamentally acquired through practices and applications. Engineering students realize lack of the experience and the knowledge necessary for evaluating optimal solutions or to perform the necessary detailed analysis to achieve these targeted optimal solutions to be reached. Engineering students must begin at the outset to learn and practice methods of the kind of orderly thinking into which their added (cumulative) knowledge can eventually be integrated.

Chief components of the industrial engineering curriculum may include such courses as drafting, strategies of materials usage, development of sensitivity to product form, the use of light, shade and color in design, product aesthetics and subjective creativity, product form for mass production, space analysis as a means of visual communication, industrial graphics, the use of two-and three-dimensional mockups (volumetric models). Industrial engineering has been defined as the imaginative development of manufactured products and product systems that serve the physical needs and satisfy the psychological and sociological desires of purchasing-people (customer, consumer) [1].

3. Human Engineering

It can be seen that industrial engineering curricula seem to present a broad, almost philosophical, premise in design concepts. Use of such phrasing in curricula description as humane performance justifying a product's existence presents more of an abstraction than a technical basis for human factors. A review of industrial engineering curricula in general tends to indicate the need for introducing more fundamental factors of technology. The best means of presenting and assimilating this point of view for the industrial engineering student might be an integrative one. Thus, every phase of an industrial engineer's training should ideally also incorporate valid human engineering principles. The abstract regard for "humanics" in industrial engineering must then be translated into meaningful perceptual-motor terms that can be realistically applied to design configuration of curricula [2].

All engineering training programs emphatically assume the value and importance of designing for human needs; technical human data for design interfaces, however, are generally a neglected facet of engineering curricula. These should become an emphatic part of the information-gathering phase of design. The information gathering phase in any engineering project should also ideally incorporate valid human engineering principles to be applied in the design approach.

In teaching ergonomics (human factors to second year students) we found both faculty and students to be keenly interested in the human factors aspects of drafting. Generic human factors background was lacking in their training. Technical drawing student requires simplified and expedient techniques for immediate drafting and design applications which must be given during the first year of training.

Human engineering is commonly recognized to be an important part of the development process in most aerospace/military products. Human factors in the design of civilian products and industrial operations are only beginning to receive such attention, largely due to publicized incidents where human made error has been found to be responsible for accidents. I.e., the three Mile Island nuclear plant incidences [2-3].

Product life is also often severely compromised, due to the lack of good human engineering/ergonomic design. I.e., early digital watches setting and resetting were so difficult and disgusting. In modern industry, accidents have been found to be attributable to the poor ergonomics of equipment.

The important neglected human factors have resulted in hazardous operations, inconveniences and inefficiencies in both product procedures and industrial operations. Courses, which are costly in engineering, human error and poor working conditional performance and efficiency or productivity, can later be prevented. Engineering students must be sensitized to all aspects of human interfacing in the product designs. This will assure that a well-rounded and mature perspective on human factors will be incorporated by assuming such responsibility at the beginning of technical drawing.

4. The Model

Statistical model is prepared with 12 verbal questions (ln Likert Format) about 200 engineering students of Istanbul Arel University, Yıldız Technical University, Okan University and Golden Horn (Haliç) University. Questions are given in table below: The model we used in implicit form: $y= ax+ bz + cw + \ldots$ [4-5].

Statistical analyses of the questionnaire (Table 1) are summarized in Table 2. And Minitab outputs are given in Figs. 1-15.

Fig. 1 shows one-way Anova male and female versus graduated. Fig. 2 shows that one-way Anova

Table 1 Questionnaire

1.Male ☐ Female ☐

2. High school graduated

High School ☐ Anatolian High School ☐ Science School ☐ College ☐

3. Repetition in technical drawing class

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

4.I believe that with the knowledge I gain from the lesson that I took in a semester will make me successful in business life.	Completely disagree	Disagree	Indifferent	Agree	Completely Agree
5.I believe that with the help of this lesson it is more possible for me to find a job.	Completely disagree	Disagree	Indifferent	Agree	Completely Agree
6.Technical drawing lesson helped me to have training.	Completely disagree	Disagree	Indifferent	Agree	Completely Agree
7.Technical drawing lesson helped to prepare a presentation for project.	Completely disagree	Disagree	Indifferent	Agree	Completely Agree
8.I believe that computer aided education will help me to design.	Completely disagree	Disagree	Indifferent	Agree	Completely Agree
9.I think technical drawing has relationship with other lessons and helps me to comprehend these lessons.	Completely disagree	Disagree	Indifferent	Agree	Completely Agree
10.When I see an object or a product I perceive it with its dimensions in my mind.	Completely disagree	Disagree	Indifferent	Agree	Completely Agree
11.I think computer aided education must be given more place in the syllabus of technical drawing lesson.	Completely disagree	Disagree	Indifferent	Agree	Completely Agree
12.I think standart technical drawing education must be given more place in the syllabus of technical drawing lesson.	Completely disagree	Disagree	Indifferent	Agree	Completely Agree

Table 2 Descriptive analysis of questionnaire.

Descriptive Statistics: C1; C2; C3; C4; C5; C6; C7; C8; C9; C10; C11; C12

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
C1	193	4	1,4560	0,0359	0,4994	1,0000	1,0000	1,0000	2,0000
C2	193	4	2,472	0,109	1,517	1,000	1,500	2,000	3,000
C3	192	5	1,3906	0,0599	0,8304	1,0000	1,0000	1,0000	2,0000
C4	193	4	3,0207	0,0777	1,0799	1,0000	2,0000	3,0000	4,0000
C5	193	4	2,9534	0,0858	1,1915	1,0000	2,0000	3,0000	4,0000
C6	189	8	2,6614	0,0798	1,0972	1,0000	2,0000	3,0000	3,0000
C7	188	9	2,8351	0,0833	1,1420	1,0000	2,0000	3,0000	4,0000
C8	191	6	3,7853	0,0803	1,1102	1,0000	3,0000	4,0000	5,0000
C9	190	7	2,5158	0,0803	1,1066	1,0000	2,0000	2,0000	3,0000
C10	193	4	3,6166	0,0821	1,1402	1,0000	3,0000	4,0000	4,0000
C11	193	4	4,1658	0,0779	1,0818	1,0000	4,0000	4,0000	5,0000
C12	193	4	2,7668	0,0891	1,2385	1,0000	2,0000	3,0000	4,0000

Variable	Maximum
C1	2,0000
C2	6,000
C3	5,0000
C4	5,0000

```
One-way ANOVA: C1 versus C2
Source   DF      SS     MS     F      P
C2        5   2,214  0,443  1,81  0,112
Error   187  45,661  0,244
Total   192  47,876
S = 0,4941   R-Sq = 4,62%   R-Sq(adj) = 2,07%
                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level    N    Mean   StDev  -----+---------+---------+---------+----
1       48  1,5208  0,5049              (----*---)
2       95  1,4000  0,4925           (---*--)
3        8  1,5000  0,5345       (----------*----------)
4        8  1,8750  0,3536                   (-----------*----------)
5       21  1,4762  0,5118          (------*------)
6       13  1,3077  0,4804  (--------*--------)
                            -----+---------+---------+---------+----
                               1,20      1,50      1,80      2,10
Pooled StDev = 0,4941
```

Fig. 1 One-way Anova male and female vs. graduated.

```
One-way ANOVA: C2 versus C4
Source   DF      SS    MS     F      P
C4        4   18,55  4,64  2,06  0,088
Error   188  423,54  2,25
Total   192  442,09
S = 1,501   R-Sq = 4,20%   R-Sq(adj) = 2,16%
                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N   Mean  StDev  --------+---------+---------+---------+-
1      25  2,120  1,054  (-------*--------)
2      24  2,917  1,692               (--------*-------)
3      77  2,455  1,483          (----*----)
4      56  2,286  1,522      (-----*----)
5      11  3,364  1,912                (------------*------------)
                         --------+---------+---------+---------+-
                               2,10      2,80      3,50      4,20
Pooled StDev = 1,501
```

Fig. 2 One-way Anova graduated vs. repetition.

```
One-way ANOVA: C1 versus C11
Source   DF      SS     MS     F      P
C11       4   3,132  0,783  3,29  0,012
Error   188  44,744  0,238
Total   192  47,876
S = 0,4879   R-Sq = 6,54%   R-Sq(adj) = 4,55%
                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level    N    Mean   StDev  ---+---------+---------+---------+------
1        9  1,5556  0,5270    (------------*------------)
2        9  1,7778  0,4410             (------------*------------)
3       18  1,5556  0,5113         (--------*--------)
4       62  1,2903  0,4576  (----*----)
5       95  1,5053  0,5026           (---*---)
                            ---+---------+---------+---------+------
                             1,25      1,50      1,75      2,00
Pooled StDev = 0,4879
```

Fig. 3 Differentiation of drawing w.r.t. sex.

```
One-way ANOVA: C10 versus C12
Source   DF      SS    MS     F      P
C12       4   18,28  4,57  3,71  0,006
Error   188  231,35  1,23
Total   192  249,63
S = 1,109   R-Sq = 7,32%   R-Sq(adj) = 5,35%
                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N   Mean  StDev  ------+---------+---------+---------+---
1      35  3,057  1,282  (------*-------)
2      52  3,577  1,126             (------*-----)
3      47  3,702  0,976                (-----*-----)
4      41  3,805  1,100                 (------*------)
5      18  4,167  1,043                     (----------*----------)
                         ------+---------+---------+---------+---
                             3,00      3,50      4,00      4,50
Pooled StDev = 1,109
```

Fig. 4 Understanding vs. implication.

```
One-way ANOVA: C11 versus C12
Source   DF      SS    MS     F      P
C12       4    9,50  2,37  2,07  0,086
Error   188  215,20  1,14
Total   192  224,69
S = 1,070   R-Sq = 4,23%   R-Sq(adj) = 2,19%
                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N   Mean  StDev  -----+---------+---------+---------+---
1      35  4,057  1,494  (------*------)
2      52  4,173  1,133      (----*-----)
3      47  4,021  1,011  (-----*------)
4      41  4,122  0,748    (-----*------)
5      18  4,833  0,514               (---------*---------)
                         -----+---------+---------+---------+---
                            4,00      4,50      5,00      5,50
Pooled StDev = 1,070
```

Fig. 5 Approval of given more time to technical drawing.

```
One-way ANOVA: C8 versus C9
Source   DF      SS     MS      F      P
C9        4   46,52  11,63  11,47  0,000
Error   185  187,63   1,01
Total   189  234,15
S = 1,007   R-Sq = 19,87%   R-Sq(adj) = 18,13%
                         Individual 95% CIs For Mean Based on Pooled StDev
Level   N   Mean  StDev  +---------+---------+---------+---------
1      41  3,098  1,393  (---*----)
2      56  3,536  1,026        (---*--)
3      52  4,038  0,791               (---*---)
4      36  4,472  0,696                    (----*----)
5       5  4,600  0,894              (------------*-----------)
                         +---------+---------+---------+---------
                       2,80      3,50      4,20      4,90
Pooled StDev = 1,00
```

Fig. 6 Understanding and use of drawing.

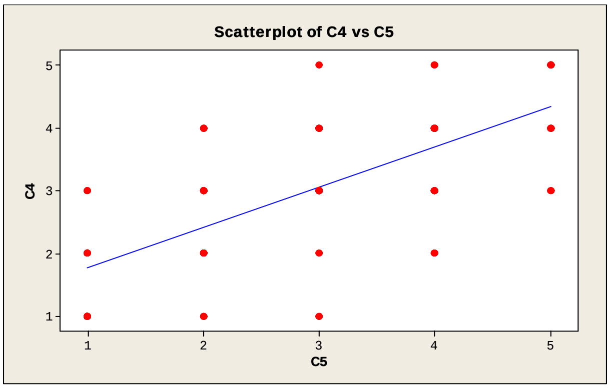

Fig. 7 Success vs. proof of education.

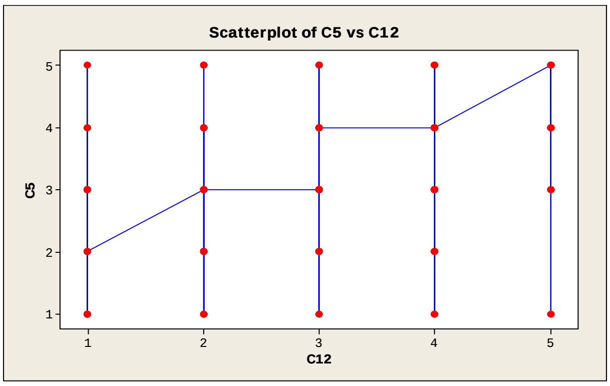

Fig. 8 Scatterplots of C5 vs. C12 job hunting vs. education.

```
Fractional Factorial Design
Factors:  5   Base Design:        5; 8   Resolution:  III
Runs:     8   Replicates:            1   Fraction:    1/4
Blocks:   1   Center pts (total):    0
* NOTE * Some main effects are confounded with two-way interactions.
Design Generators: D = AB; E = AC
Alias Structure
I + ABD + ACE + BCDE
A + BD + CE + ABCDE
B + AD + CDE + ABCE
C + AE + BDE + ABCD
D + AB + BCE + ACDE
E + AC + BCD + ABDE
BC + DE + ABE + ACD
BE + CD + ABC + ADE
```

Fig. 9 Fractional factorial design.

```
Fractional Factorial Design

Factors:  12   Base Design:        12; 16   Resolution:    III
Runs:     16   Replicates:              1   Fraction:    1/256
Blocks:    1   Center pts (total):      0
* NOTE * Some main effects are confounded with two-way interactions.
Design Generators: E = ABC; F = ABD; G = ACD; H = BCD; J = ABCD; K = AB;
                   L = AC; M = AD
Alias Structure (up to order 3)
I + ABK + ACL + ADM + AHJ + BEL + BFM + BGJ + CEK + CFJ + CGM + DEJ + DFK + DGL
     + EHM + FHL + GHK

A + BK + CL + DM + HJ + BCE + BDF + BGH + CDG + CFH + DEH + EFG + EJM + EKL +
     FJL + FKM + GJK + GLM
B + AK + EL + FM + GJ + ACE + ADF + AGH + CDH + CFG + CJM + CKL + DEG + DJL +
     DKM + EFH + HJK + HLM
C + AL + EK + FJ + GM + ABE + ADG + AFH + BDH + BFG + BJM + BKL + DEF + DJK +
     DLM + EGH + HJL + HKM
D + AM + EJ + FK + GL + ABF + ACG + AEH + BCH + BEG + BJL + BKM + CEF + CJK +
     CLM + FGH + HJM + HKL
E + BL + CK + DJ + HM + ABC + ADH + AFG + AJM + AKL + BDG + BFH + CDF + CGH +
     FJK + FLM + GJL + GKM
F + BM + CJ + DK + HL + ABD + ACH + AEG + AJL + AKM + BCG + BEH + CDE + DGH +
     EJK + ELM + GJM + GKL
G + BJ + CM + DL + HK + ABH + ACD + AEF + AJK + ALM + BCF + BDE + CEH + DFH +
     EJL + EKM + FJM + FKL
H + AJ + EM + FL + GK + ABG + ACF + ADE + BCD + BEF + BJK + BLM + CEG + CJL +
     CKM + DFG + DJM + DKL
J + AH + BG + CF + DE + AEM + AFL + AGK + BCM + BDL + BHK + CDK + CHL + DHM +
     EFK + EGL + FGM + KLM
K + AB + CE + DF + GH + AEL + AFM + AGJ + BCL + BDM + BHJ + CDJ + CHM + DHL +
     EFJ + EGM + FGL + JLM
L + AC + BE + DG + FH + AEK + AFJ + AGM + BCK + BDJ + BHM + CDM + CHJ + DHK +
     EFM + EGJ + FGK + JKM
M + AD + BF + CG + EH + AEJ + AFK + AGL + BCJ + BDK + BHL + CDL + CHK + DHJ +
     EFL + EGK + FGJ + JKL
AE + BC + DH + FG + JM + KL + ABL + ACK + ADJ + AHM + BEK + BFJ + BGM + CEL +
     CFM + CGJ + DEM + DFL + DGK + EHJ + FHK + GHL
AF + BD + CH + EG + JL + KM + ABM + ACJ + ADK + AHL + BEJ + BFK + BGL + CEM +
     CFL + CGK + DEL + DFM + DGJ + EHK + FHJ + GHM
AG + BH + CD + EF + JK + LM + ABJ + ACM + ADL + AHK + BEM + BFL + BGK + CEJ +
     CFK + CGL + DEK + DFJ + DGM + EHL + FHM + GHJ
```

Fig. 10 Fractional factorial design.

graduated versus repetition. Fig. 3 shows one-way Anova differentiation w.r.t. sex. Fig. 4 shows one-way Anova understanding versus application. Fig. 5 shows that approval of more time given to technical drawing. Fig. 6 is understanding versus drawing.

Also, Figs. 7-10 show success versus proof of education, scatterplots versus job hunting, fractional factorial design respectively. On the other hand, Figs. 11-12 illustrate central composite designs for different factors. Figs. 13-14 illustrate boxplots and histograms. Fig. 15 is the output of one sample Z of repetition (question 3).

Table 3 and Table 4 list analysis of variance and factor analysis of questions 1-12.

```
Central Composite Design
Factors:          3     Replicates:      1
Base runs:       20     Total runs:     20
Base blocks:      1     Total blocks:    1
Two-level factorial:  Full factorial
Cube points:               8
Center points in cube:     6
Axial points:              6
Center points in axial:    0
Alpha: 1,68179
```

Fig. 11 Central composite design.

```
Central Composite Design
Factors:        10     Replicates:       1
Base runs:     158     Total runs:     158
Base blocks:     1     Total blocks:     1
Two-level factorial: Eighth fraction
Cube points:              128
Center points in cube:     10
Axial points:              20
Center points in axial:     0
Alpha: 3,36359
```

Fig. 12 Central composite design.

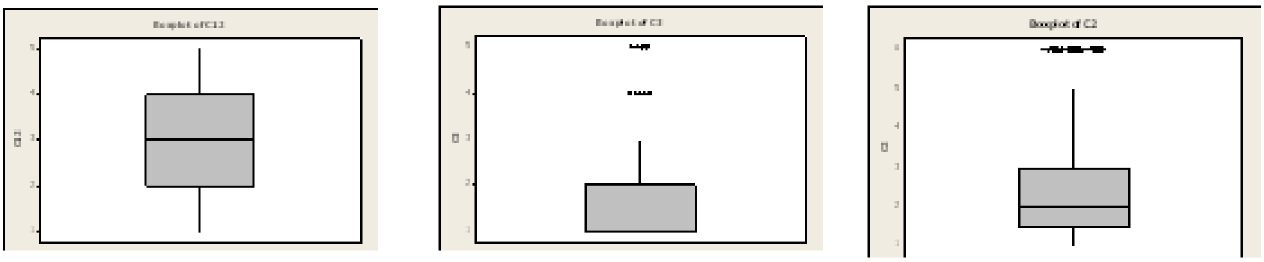

Fig. 13 Boxplots and histogram of questions 1 to 2.

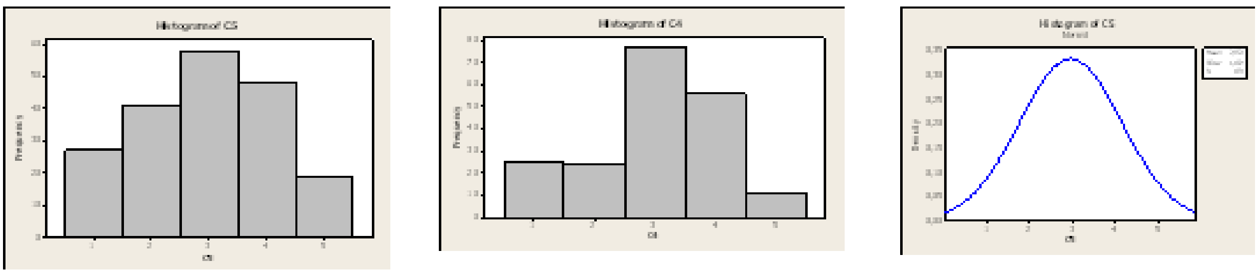

Fig. 14 Boxplot and histograms of graduations vs. success.

One-Sample Z: C3

The assumed standard deviation = 0,8304

Variable	N	Mean	StDev	SE Mean	95% CI
C3	192	1,3906	0,8304	0,0599	(1,2732; 1,5081)

Fig. 15 Analysis of reputation of drawing classes.

Table 3 Anova.

Analysis of Variance

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	10	3,2388	3,2388	0,323877	1,32663	0,219431
C3	1	0,1152	0,1940	0,193978	0,79455	0,373950
C4	1	1,3085	0,8118	0,811824	3,32531	0,069927
C5	1	0,0127	0,1552	0,155152	0,63552	0,426419
C6	1	0,0000	0,1444	0,144386	0,59142	0,442907
C7	1	0,5425	0,4374	0,437353	1,79144	0,182487
C8	1	0,0488	0,0192	0,019202	0,07865	0,779464
C9	1	0,0665	0,0237	0,023674	0,09697	0,755865
C10	1	0,2543	0,3574	0,357436	1,46409	0,227912
C11	1	0,3255	0,3440	0,343953	1,40886	0,236854
C12	1	0,5647	0,5647	0,564664	2,31292	0,130108
Error	175	42,7236	42,7236	0,244135		
Lack-of-Fit	172	42,2236	42,2236	0,245486	1,47292	0,433936
Pure Error	3	0,5000	0,5000	0,166667		
Total	185	45,9624				

Fits and Diagnostics for Unusual Observations

Obs	C1	Fit	SE Fit	Residual	St Resid	
103	1	1,12927	0,229470	-0,129268	-0,295413	X

X denotes an observation whose X value gives it large leverage.

Table 4 Factor analysis question 1 to 12.

Factor Analysis: C1; C2; C3; C4; C5; C6; C7; C8; C9; C10; C11; C12

Maximum Likelihood Factor Analysis of the Correlation Matrix

* WARNING * No convergence in 25 steps. Results from last iteration.

Unrotated Factor Loadings and Communalities

186 cases used 11 cases contain missing values

Variable	Factor1	Factor2	Communality
C1	0,109	0,066	0,016
C2	-0,016	-0,041	0,002
C3	-0,100	0,130	0,027
C4	0,676	0,453	0,662
C5	0,756	0,393	0,726
C6	0,968	-0,149	0,959
C7	0,773	0,170	0,627
C8	0,554	0,357	0,434
C9	0,621	0,344	0,504
C10	0,444	0,284	0,277
C11	0,338	0,305	0,207
C12	0,385	0,251	0,211
Variance	3,7384	0,9163	4,6547
% Var	0,312	0,076	0,388

Factor Score Coefficients

Variable	Factor1	Factor2
C1	0,004	0,019
C2	-0,001	-0,012
C3	-0,003	0,037
C4	0,065	0,373
C5	0,089	0,400
C6	0,767	-1,020
C7	0,067	0,127
C8	0,032	0,176
C9	0,040	0,193
C10	0,020	0,109
C11	0,014	0,107
C12	0,016	0,088

5. Conclusions

Technical drawing and drafting courses must be taught in all engineering departments. First term, teaching drawing and terminology in technical drawing and introduction to computer usage in engineering. Second term CAD, CID, CAE etc. could easily be covered with 2 and 3 dimensions. It is well understood from statistical analysis that without TDT we cannot graduate engineer, especially industrial engineers. We also should include in the course human side of engineering, ergonomics and work design for competing in the market. Credit hours for the course could be [(1-2-0) 2 and (1-2-0) 2] or (2-4-0) 4 credits one term. The classroom would be clear, light, quite and 20 ℃ temperature. It also must have lockers and drawing boards and tables with projections and video systems. Statistical analysis shows that questions were consistent, valid and reliable for technical drawing and design courses.

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