Ways of Learning Engineering Statistics after Leaving College: a Survey

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Outline

- Problem statement
- Typical college programs
- Certification requirements
- Bridging the gap: self-learning
- The survey questionnaire
- Survey main results
- Characteristics and Validation
- Conclusions

Problem Statement

Engineering statistics is:

- Insufficiently taught in undergraduate
  - Very few courses (mainly one or two)
  - Or none at all (no courses taken)
- Engineers have to study stats on their own
  - As best they can, using different means
  - As practicing professionals (after college)
- Because they need it in their work!

Examples of Undergraduate Engineering Curriculums:

- Mechanical Engineering
  - One course, Math Dept.
- Civil Engineering
  - One course, Math Dept.
- Electrical Engineering
  - One course, Math Dept.
- Computer Science
  - One course, taught internally

Undergrad Statistics Course Example

•Descriptive Stats (Chs. 1& 2): Examples of uses of statistics in problem solving Frequency distributions, Pareto, Dot, Stem-and-leaf and other diagrams and graphs; descriptive measures and their calculations. Case study.
•Probability (Ch. 3): sample spaces, events, counting rules, axioms of probabilities, elementary theorems, conditional probability, Bayes theorem, mathematical expectation. Case study.
•Distributions (Ch. 4): random variables, discrete distributions: Uniform, Binomial, Hypergeometric, Geometric, Multinomial, Poisson. Approximations. Chebyschev' theorem. Applications.
•Densities (Ch. 5): continuous random variables and distributions: Normal and its approximation to the Binomial, Uniform, Exponential, Log-Normal, Gamma, Weibull. Joint distributions. Checking for Normality. Variable Transformations.
•Sampling Distributions (Ch. 6): populations and samples, distributions of the mean and the variance; Student t, F and Chi Square distributions.
•Inferences Concerning the Mean (Ch. 7): point and interval estimation.
•Some applications in Reliability engineering (Ch. 15). Text: Johnson's.

Graduate Statistics Course Example

•Review of Probability, Random Variables, Probability Distributions (Ch. 3 to 6): Discrete distributions; Uniform, Binomial, Multinomial Hypergeometric and Poisson. Continuous distributions: Normal, Exponential, Gamma, Weibull, Approximations.
•Sampling Distributions (Ch. 8): populations and samples; parameters and statistics; sampling distributions (t, F, Chi-Square).
•Point and Interval Estimation (Ch. 9, 16): estimation of mean, proportion and variance of a single sample; paired samples; difference between two means/proportion; ratio of two variances. Quality Control. Applications.
•Hypothesis Testing (Ch. 10): theoretical development and framework, tests for the mean, proportion and variance of a single population; tests for two means, two proportions and two variances. One and two sided tests. Goodness of Fit; Sample size.
•Correlation and Linear Regression (Ch. 11 and 12): simple linear regression, including model verification, residual analysis, multiple regression, selection of variables, choosing the best model. Lack of Fit. Variable transformations.
•Analysis (ANOVA) of Variance (Ch. 13): one-way and two way ANOVAs, randomized experiments; random blocks; Factorial designs; model verification and residual analysis.
•Other topics (Design of Experiments; Non Parametrics) as time allows (Walpole/Myers)

Examples of Certification Statistics B.O.K.

- Certified Quality Engineer
  - statistical content of the exam (50%+)
  - http://www.asq.org/certification/quality-engineer/bok.html
- Certified Reliability Engineer
  - statistical content of the exam (40%+)
- American Society for Quality

How do engineers bridge the Gap between these two levels?

The survey on how engineers learn

Statistics on their own (see):

http://web.syr.edu/~jlromeu/SurveyICOTS.html

Provided some answers regarding

means used in this endeavor.

We can then expand, improve, etc.

Main Methods of Self-Learning

(1) reading books, journals, manuals or other hard copy,

(2) reading Web and Internet materials,

(3) following on-line courses or learning software, etc.,

(4) attending conferences and chapter meeting talks,

(5) pursuing preparation for professional certifications,

(6) taking short training courses,

(7) receiving mentoring from more experienced colleagues

(8) other sources: e.g. hands-on (practical) working experiences, and taking Six Sigma training

College Statistical Training

I) Among all surveyed, 16% have not taken any statistics courses in college (33% among BS), 38% took only one (38%) and 26% have taken 2 courses (24%).

II) 1/3 of those with a BS degree only, have never taken a single statistics course in college; another 1/3 of them have taken only one course. Hence, 2/3 engineers of all surveyed had either none, or very little statistical training (i.e. taken a single course).

III) Engineers that pursue graduate school have a larger opportunity of taking statistics. Only 7%, in our sample, have never taken a statistics course.

Methods Preferred

I) ***"Readings" constitute the preferred means of learning: books and journals, as well as web tutorials, provide 38% of statistics knowledge. The use of web tutorials (10%) is increasing with time: older engineers prefer hard copy, whereas younger ones read web-based material.***

II) Short courses, exam preparations for the professional certifications, and Black Belt training, are also important methods of learning statistics (33%).

III) mentoring received from more experienced colleagues and hands-on (learning by doing), also constitute frequent learning activities (22%).

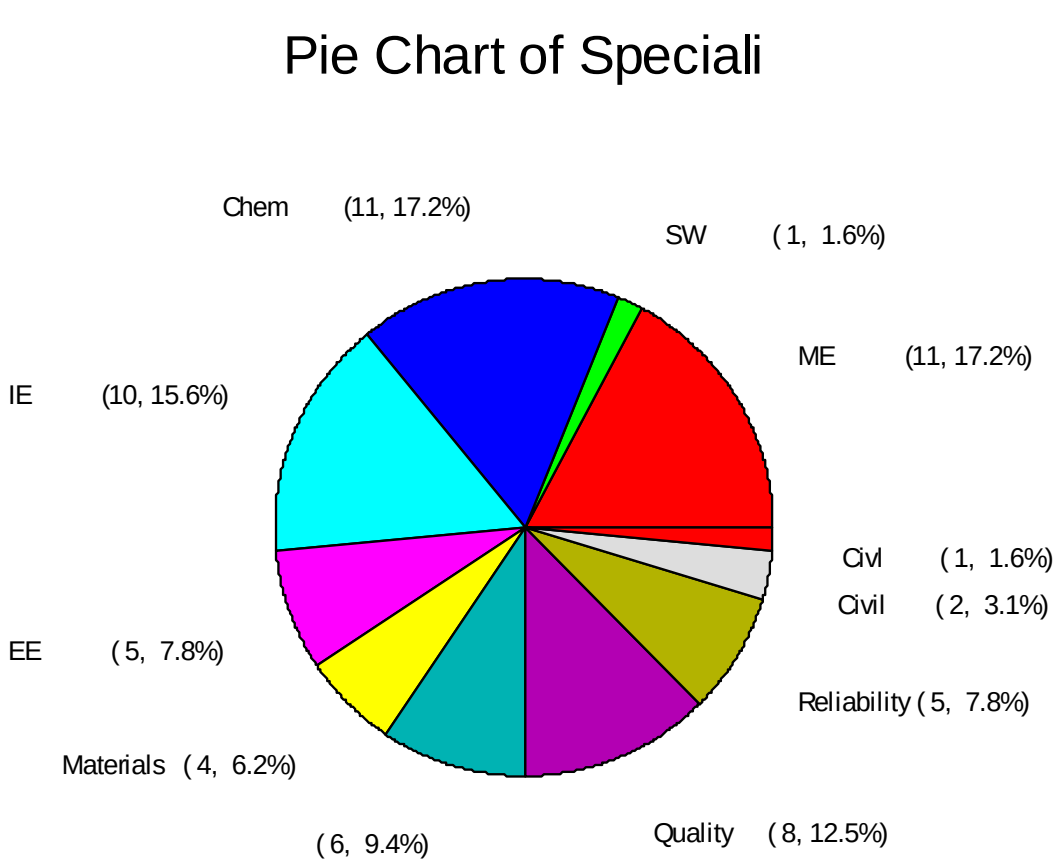
Sample Description

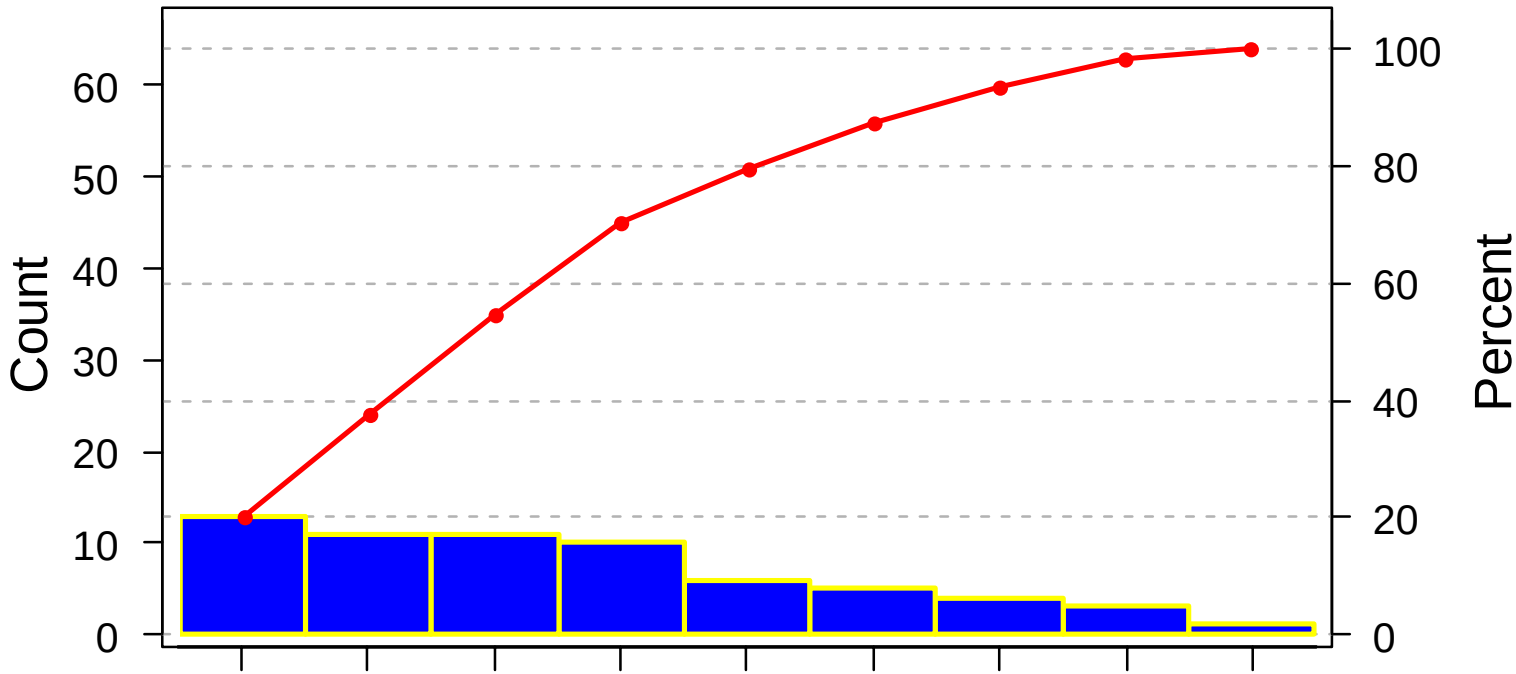
- So far, received 64 responses:
- 61 from the US
- 3 from abroad.
- 8% were females
- 56% had graduate degrees
- 60% had 16+ years of experience
- 90% were from industry.

ICOTS Survey on Practicing Engineers Statistical Education (%).

HardR	WebR	Tutor	ProfMg	Certif	ShortC	Mentor	Other	Educ	Area	Spclz	Cours	Years
15	10	5	10	10	30	20	0	BS	I	ME	2	10
35	35	0	0	0	10	20	0	BS	I	SW	2	1
70	10	10	0	0	5	5	0	PhD	I	Chm	3	7
35	15	0	0	0	25	25	0		I	Chm		
5	10	5	5	20	10	15	30		I	Chm		
5	0	0	2.5	10	2.5	0	80	BS	I	IE	1	13
25	0	0	10	15	0	10	40	MS	I	IE	2	11
10	0	0	0	75	15	0	0	BS	I	EE	0	25

Professional Specialization





Defect	Q&R	ME	Chem	IE	Unkn	EE	Materials	Civil	Others
Count	13	11	11	10	6	5	4	3	1
Percent	20.3	17.2	17.2	15.6	9.4	7.8	6.2	4.7	1.6
Cum %	20.3	37.5	54.7	70.3	79.7	87.5	93.7	98.4	100.0

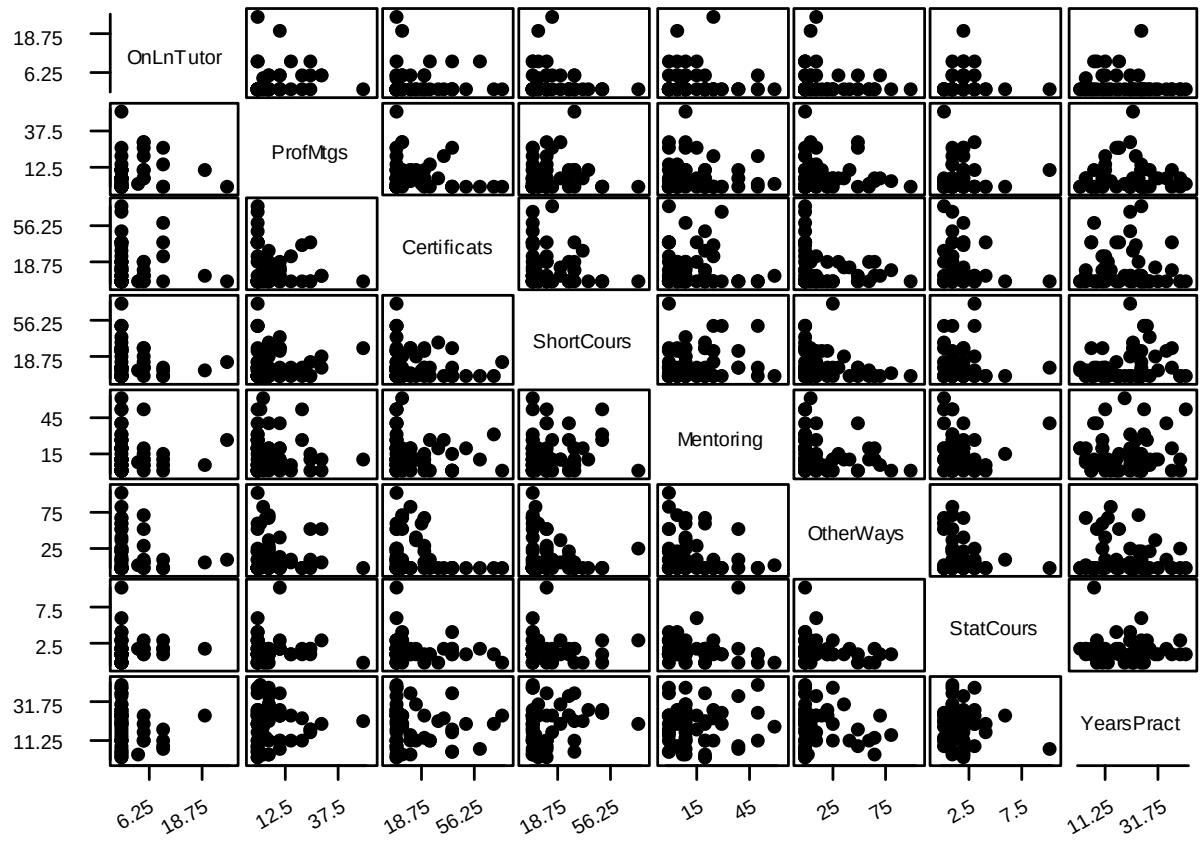
Survey v. Factual Specialty Comparison:

Specialty	*Employment*	*Percent*	Survey	[(Ei-Oi]^2/Ei
Total, All Engineers	1,462,000	100	100	
Electrical & Electronics	357,000	24	9.4	8.88
Mech&Aero	273,000	19	17.2	0.17
Civil	195,000	13	4.7	5.30
Industrial	126,000	9	15.6	4.84
Chemical	48,000	3	17.2	67.21
Materials	20,000	1	6.2	27.04
All Other	443,000	31	29.7	0.05
	Chi-Sqr(6,0.9)	= 10.64		Sum = 113.5

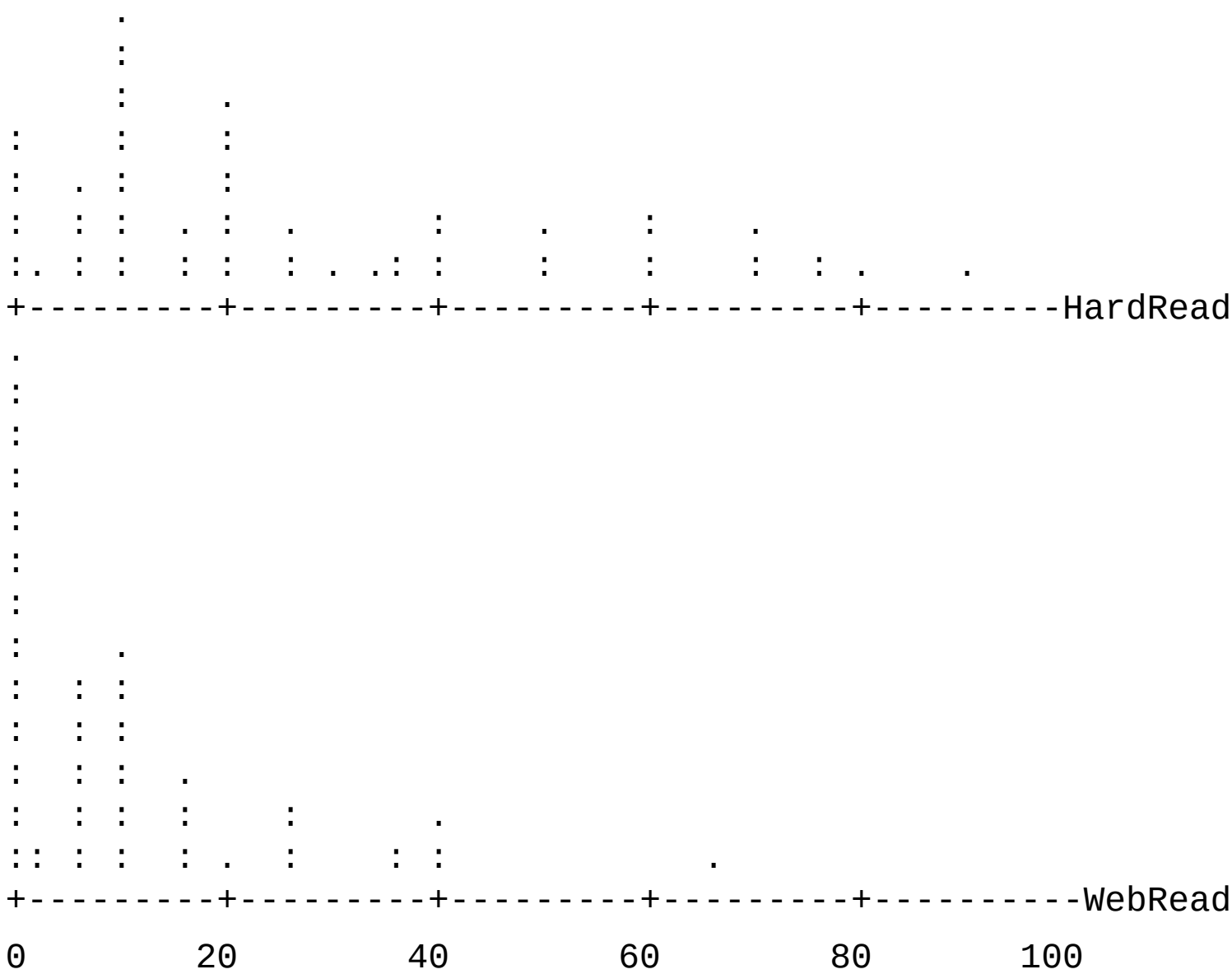
Analysis of Real Percents

Variable	N	Mean	Median	Tr Mean	StDev
HardRead	64	20.00	24.55	24.31	3.04
WebRead	64	9.58	8.07	13.22	1.65
OnLnTut	64	2.01	0.00	1.27	4.68
ProfMtgs	64	6.43	2.25	5.20	9.74
Certificat.	64	12.47	5.00	10.22	18.44
ShortCours	64	12.15	5.00	10.39	16.05
Mentoring	64	14.41	10.00	13.14	14.58
OtherWays	64	15.47	1.00	12.76	24.19
StatCours	51	1.72	1.00	1.51	1.68
YrsPract	55	18.93	20.00	18.65	10.80

Variable	Min	Max	Q1	Q3
HardRead	0.00	90.00	10.00	40.00
WebRead	0.00	65.00	0.00	13.75
OnLnTut	0.00	25.00	0.00	0.00
ProfMtgs	0.00	50.00	0.00	10.00
Certific	0.00	75.00	0.00	20.00
ShortCou	0.00	75.00	0.00	20.00
Mentorin	0.00	60.00	5.00	20.00
OtherWay	0.00	100.00	0.00	23.75
StatCour	0.00	10.00	1.00	2.00
YrsPract	1.00	42.00	10.00	25.00


OnLnTutor
ProfMtgs
Certificats
ShortCours
Mentoring
OtherWays
StatCours
YearsPract
18.75
6.25
37.5
12.5
56.25
18.75
56.25
18.75
45
15
75
25
7.5
2.5
31.75
11.25
6.25
18.75
12.5
37.5
18.75
56.25
18.75
56.25
15
45
25
75
2.5
7.5
11.25
31.75

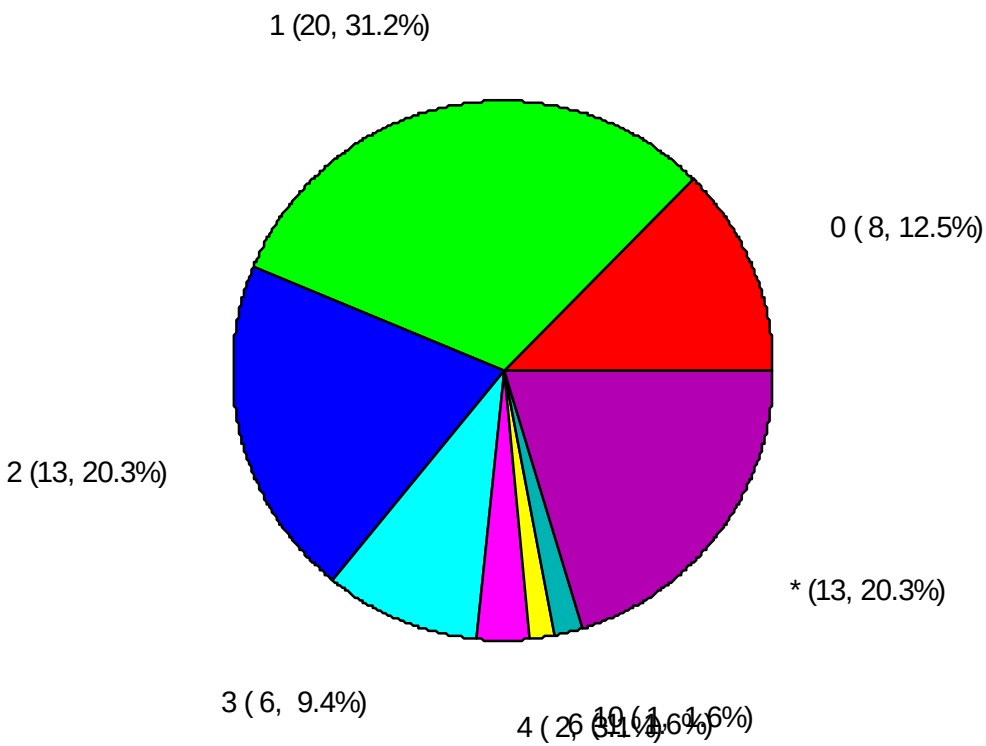
Examples of Dotplots of the Distributions:



Wilcoxon Signed Rank C.I.

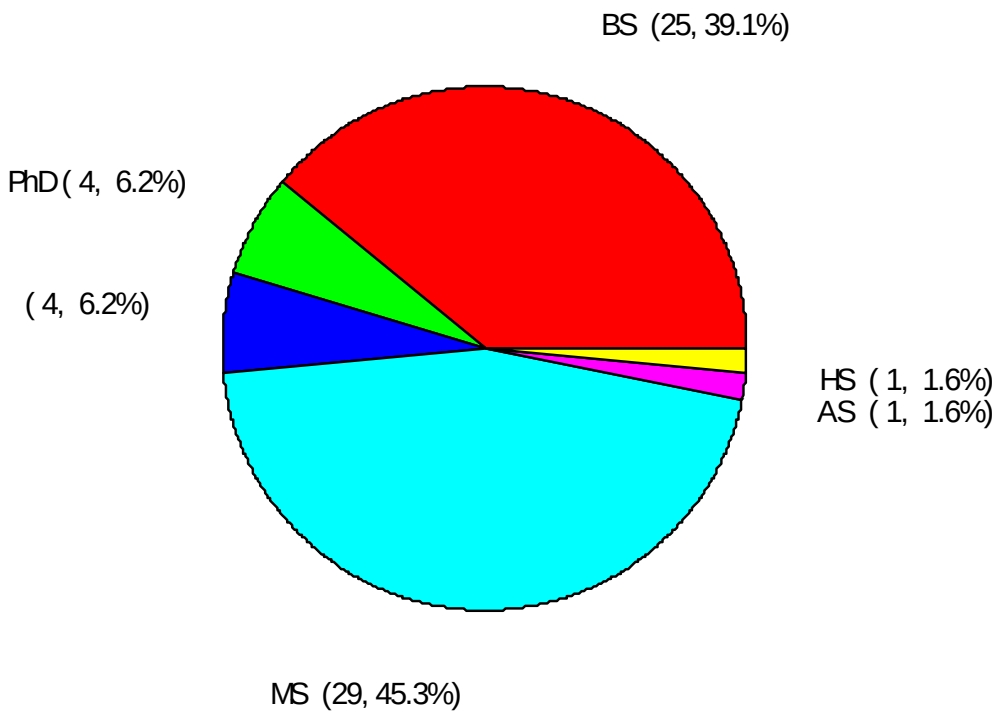
	Number N	Estimated Missing	Achieved Median	Confidence	Confidence Interval	
HardRead	64	0	22.5	95.0	(15.0,	30.0)
WebRead	64	0	7.50	95.0	(5.00,	10.00)
OnLnTuto	64	0	0.00	95.0	(0.00,	2.50)
ProfMtgs	64	0	5.00	95.0	(2.50,	6.50)
Certific	64	0	10.0	95.0	(5.0,	15.0)
ShortCou	64	0	10.0	95.0	(5.0,	15.0)
Mentorin	64	0	12.50	95.0	(10.00,	15.00)
OtherWay	64	0	10.0	95.0	(5.0,	17.5)
StatCour	51	13	1.50	95.0	(1.00,	2.00)
YearsPra	55	9	18.50	95.0	(15.50,	22.50)

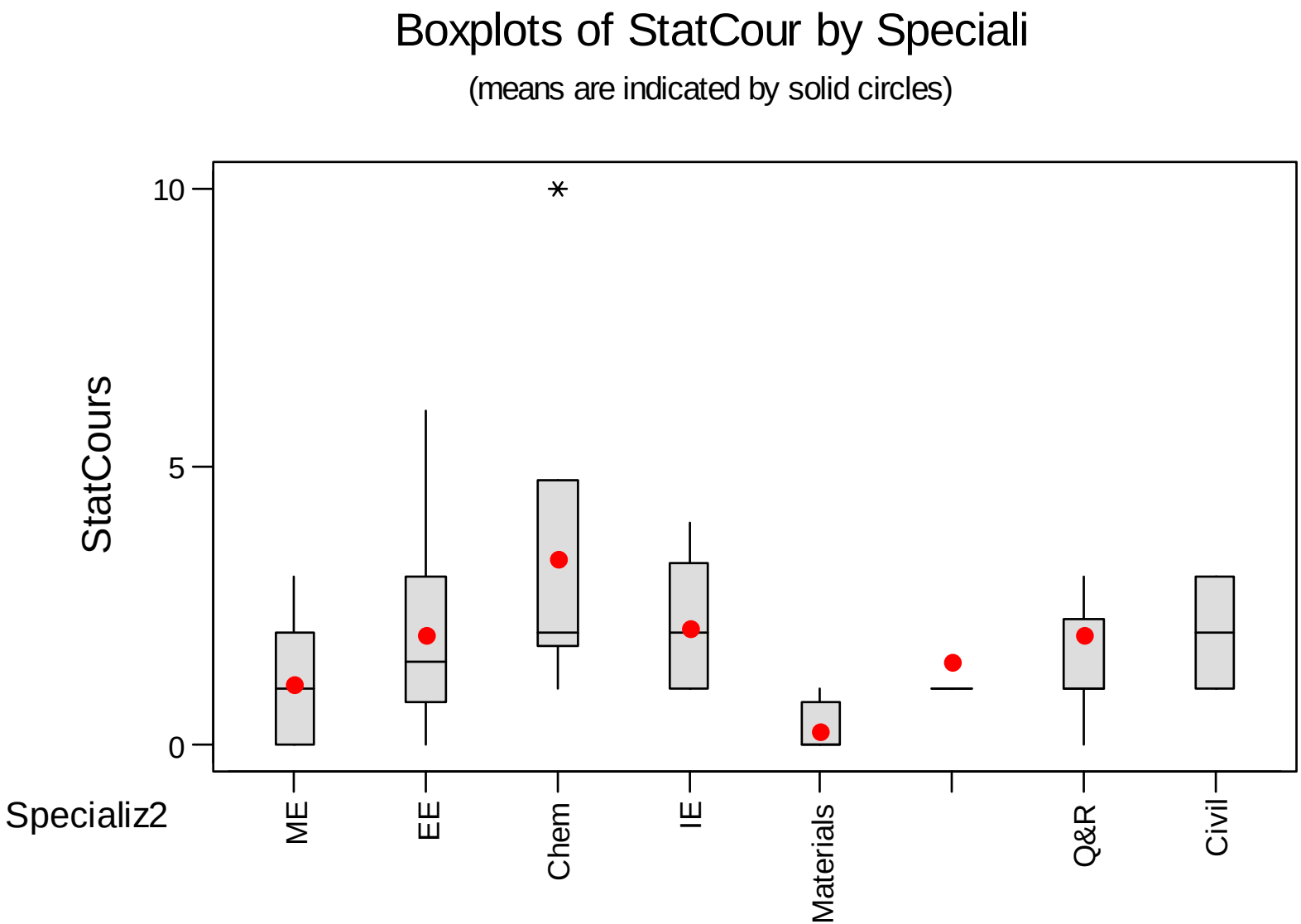
Statistics Courses Taken:

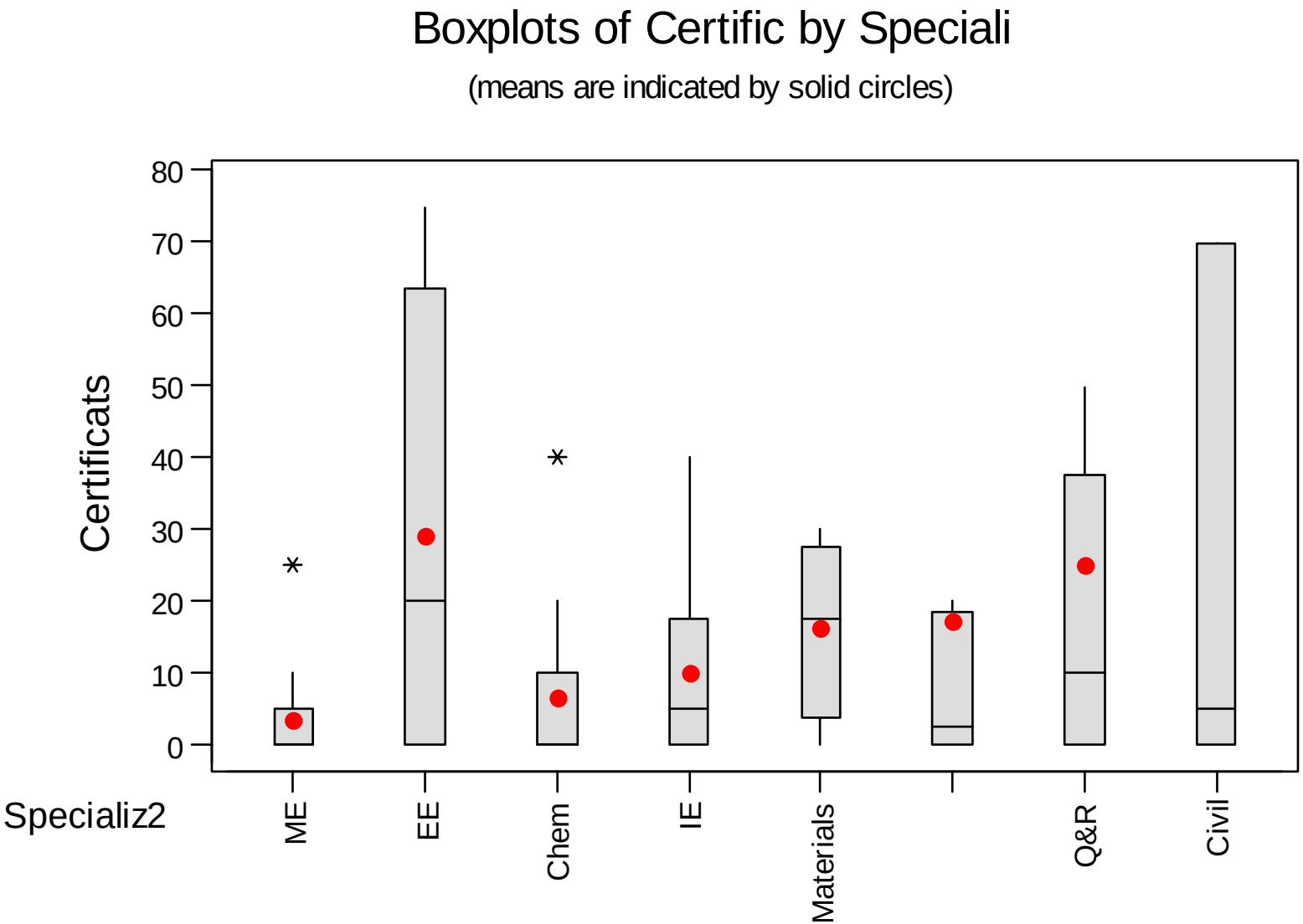


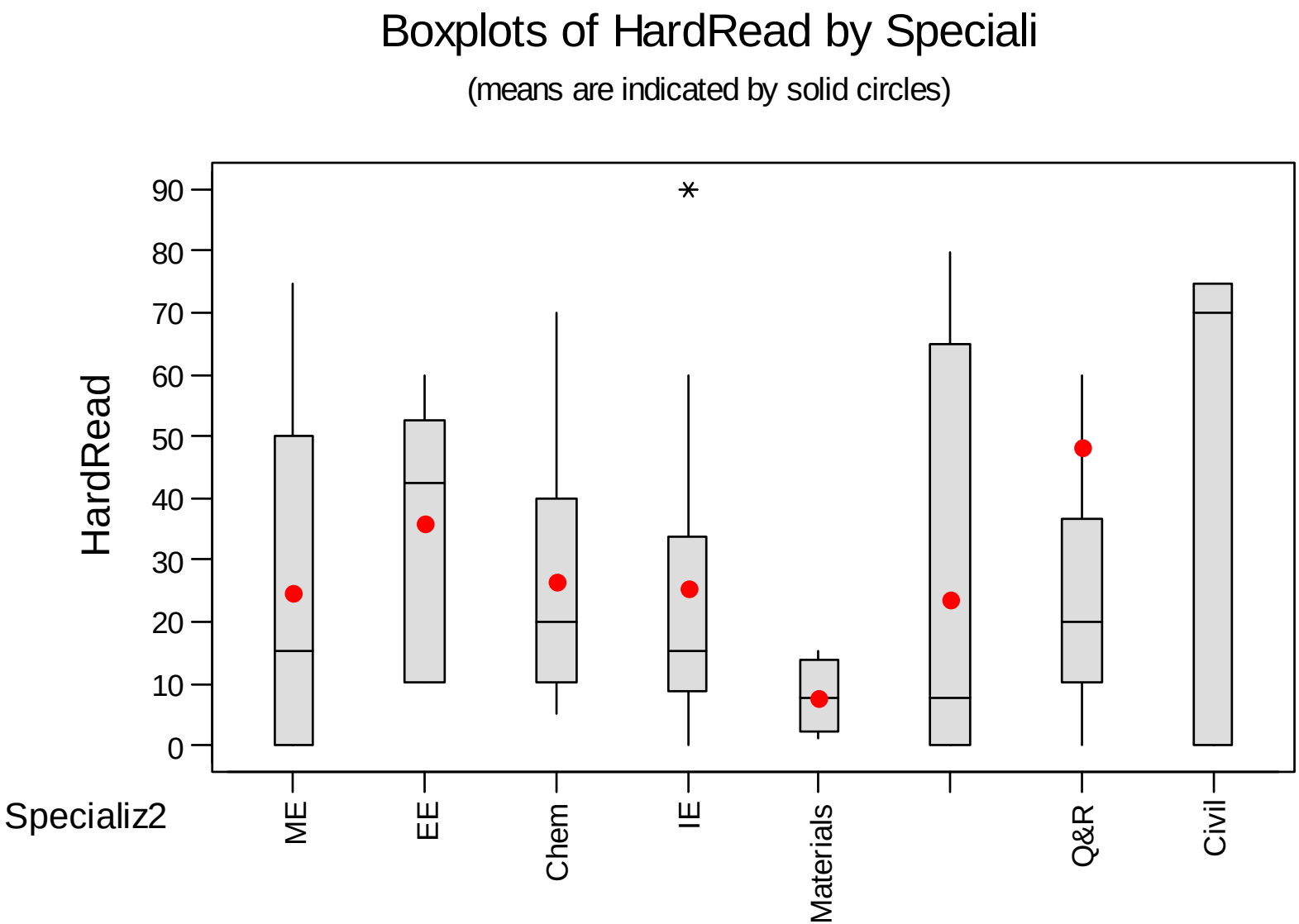
Educational Background

Pie Chart of Educatio




Boxplots of StatCour by Speciali
(means are indicated by solid circles)
StatCours
10
5
0
Specializ2
ME
EE
Chem
IE
Materials
Q&R
Civil


Boxplots of Certific by Speciali
(means are indicated by solid circles)
Certificats
80
70
60
50
40
30
20
10
0
Specializ2
ME
EE
Chem
IE
Materials
Q&R
Civil


Boxplots of HardRead by Speciali
(means are indicated by solid circles)
HardRead
90
80
70
60
50
40
30
20
10
0
Specializ2
ME
EE
Chem
IE
Materials
Q&R
Civil

ICOTS Survey on Practicing Engineers Statistical Education (Ranks)

HardR	WebR	Tutor	ProfMg	Certif	ShortC	Mentor	Other	Educ	Area	Spclz	Cours	Years
1.5	5	3	5	5	8	7	1.5	BS	I	ME	2	10
7.5	7.5	2.5	2.5	2.5	5	6	2.5	BS	I	SW	2	1
8	6.5	6.5	2	2	4.5	4.5	2	PhD	I	Chm	3	7
8	5	2.5	2.5	2.5	6.5	6.5	2.5		I	Chm		
2	4.5	2	2	7	4.5	6	8		I	Chm		
6	2	2	4.5	7	4.5	2	8	BS	I	IE	1	13
7	2	2	4.5	6	2	4.5	8	MS	I	IE	2	11
6	3	3	3	8	7	3	3	BS	I	EE	0	25
7.5	7.5	3	3	3	3	6	3	PhD	I	Chm		
4	4	1.5	4	7	8	6	1.5	BS	I	Matr	0	21
5.5	5.5	2.5	2.5	2.5	2.5	7	8	PhD	I	Matr	0	10

Analysis of Ranks of the Percents

Variable	N	Mean	Median	Tr Mean	StDev	SE Mean
HrdRd	64	5.945	6.000	6.052	1.839	0.230
WbRd	64	4.375	4.000	4.328	1.780	0.222
OnLnTut	64	2.852	2.500	2.733	1.253	0.157
PrfMtgs	64	4.070	3.500	3.991	1.652	0.207
Certif	64	4.445	4.000	4.431	2.287	0.286
ShrtCrs	64	4.719	4.750	4.724	2.187	0.273
Mentor	64	5.234	6.000	5.284	1.886	0.236
OthrWys	64	4.359	3.500	4.319	2.383	0.298

Variable	Min	Max	Q1	Q3
HrdRd	1.500	8.000	4.500	8.000
WbRd	1.500	8.000	3.000	5.500
OnLnTut	1.000	7.500	2.000	3.500
PrfMtgs	1.500	8.000	3.000	5.000
Certif	1.000	8.000	2.500	7.000
ShrtCrs	1.000	8.000	2.500	6.875
Mentor	1.000	8.000	3.625	6.875
OthrWys	1.500	8.000	2.500	7.000

Sign confidence interval for median of rank data (1):

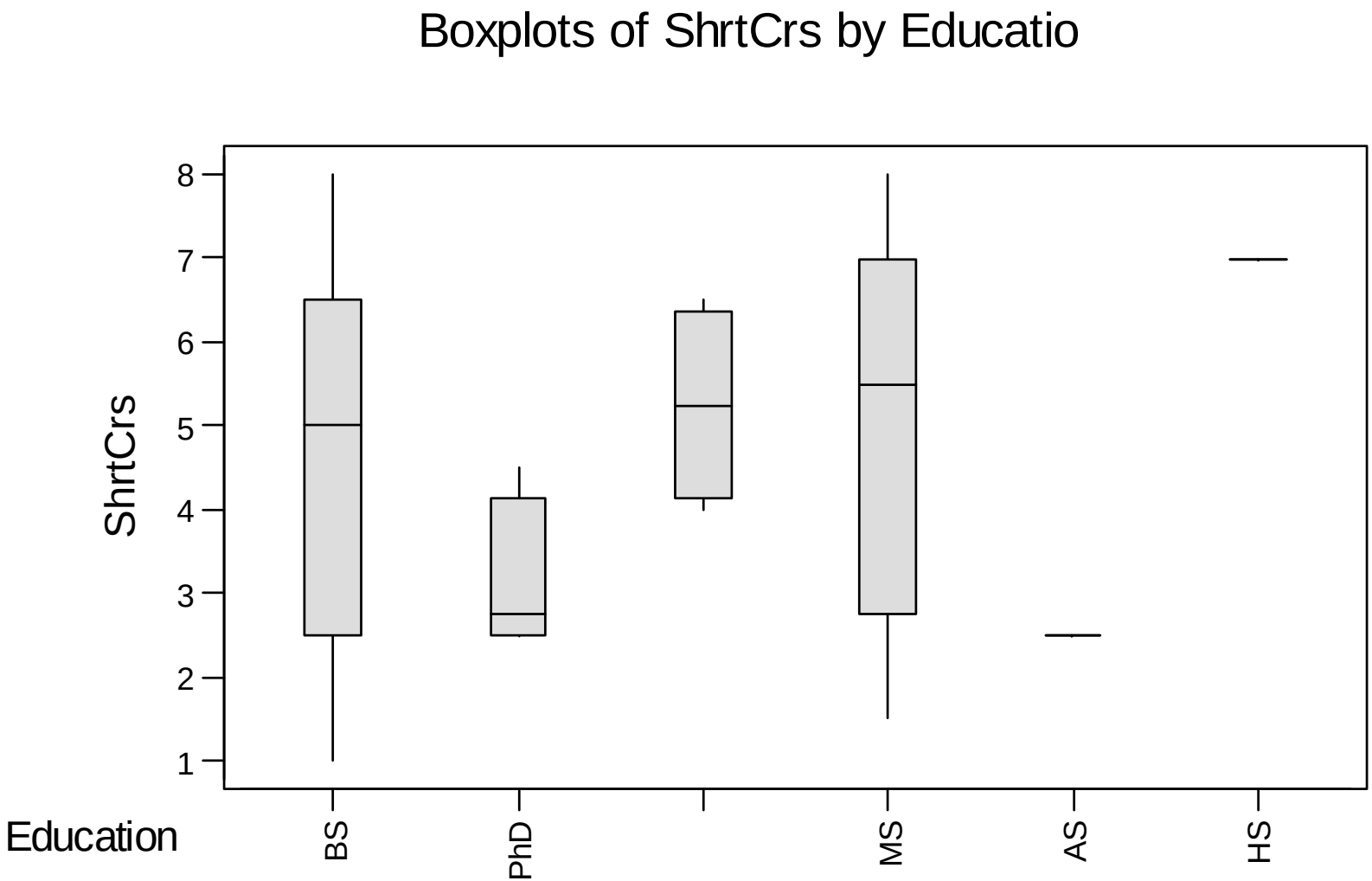
	N	N*	Median	Confidence	Confidence Interval		Pos
HrdRd	64	0	6.000	0.9392	(5.500,	7.000)	25
				0.9500	(5.500,	7.000)	NLI
				0.9664	(5.500,	7.000)	24
WbRd	64	0	4.000	0.9392	(3.500,	4.500)	25
				0.9500	(3.500,	4.641)	NLI
				0.9664	(3.500,	5.000)	24
OnLnTut	64	0	2.500	0.9392	(2.500,	3.000)	25
				0.9500	(2.500,	3.000)	NLI
				0.9664	(2.500,	3.000)	24
PrfMtgs	64	0	3.500	0.9392	(3.000,	4.500)	25
				0.9500	(3.000,	4.500)	NLI
				0.9664	(3.000,	4.500)	24

Ranks are 1 through 8, the highest being the most preferred.

Sign confidence interval for median of rank data (2):

	N	N*	Median	Confidence	Confidence Interval		Pos
Certif	64	0	4.000	0.9392	(3.000,	5.500)	25
				0.9500	(3.000,	5.500)	NLI
				0.9664	(3.000,	5.500)	24
ShrtCrs	64	0	4.750	0.9392	(3.500,	5.500)	25
				0.9500	(3.500,	5.641)	NLI
				0.9664	(3.500,	6.000)	24
Mentor	64	0	6.000	0.9392	(4.500,	6.000)	25
				0.9500	(4.500,	6.000)	NLI
				0.9664	(4.500,	6.000)	24
OthrWys	64	0	3.500	0.9392	(3.000,	4.500)	25
				0.9500	(2.859,	4.641)	NLI
				0.9664	(2.500,	5.000)	24

Ranks are 1 through 8, the highest being the most preferred.


Boxplots of ShrtCrs by Educatio
ShrtCrs
8
7
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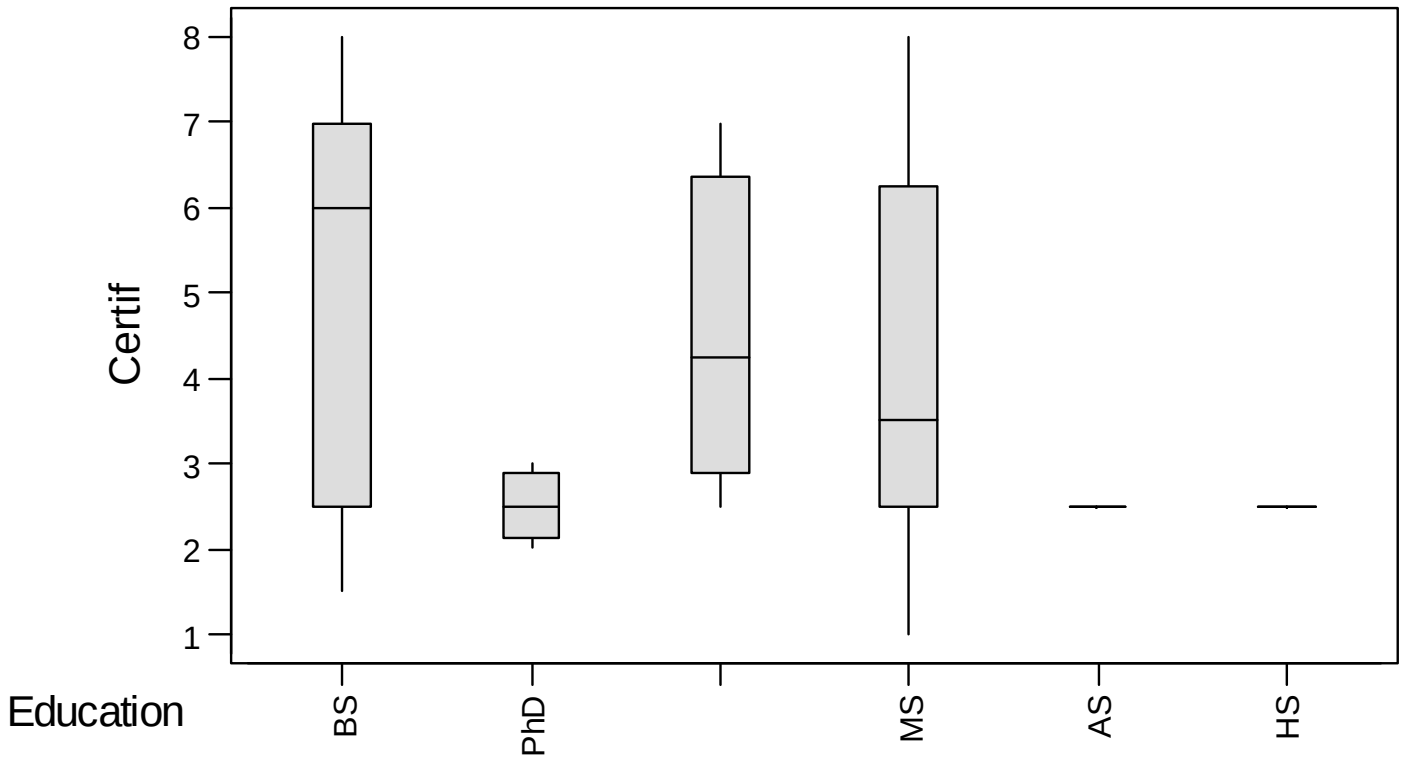
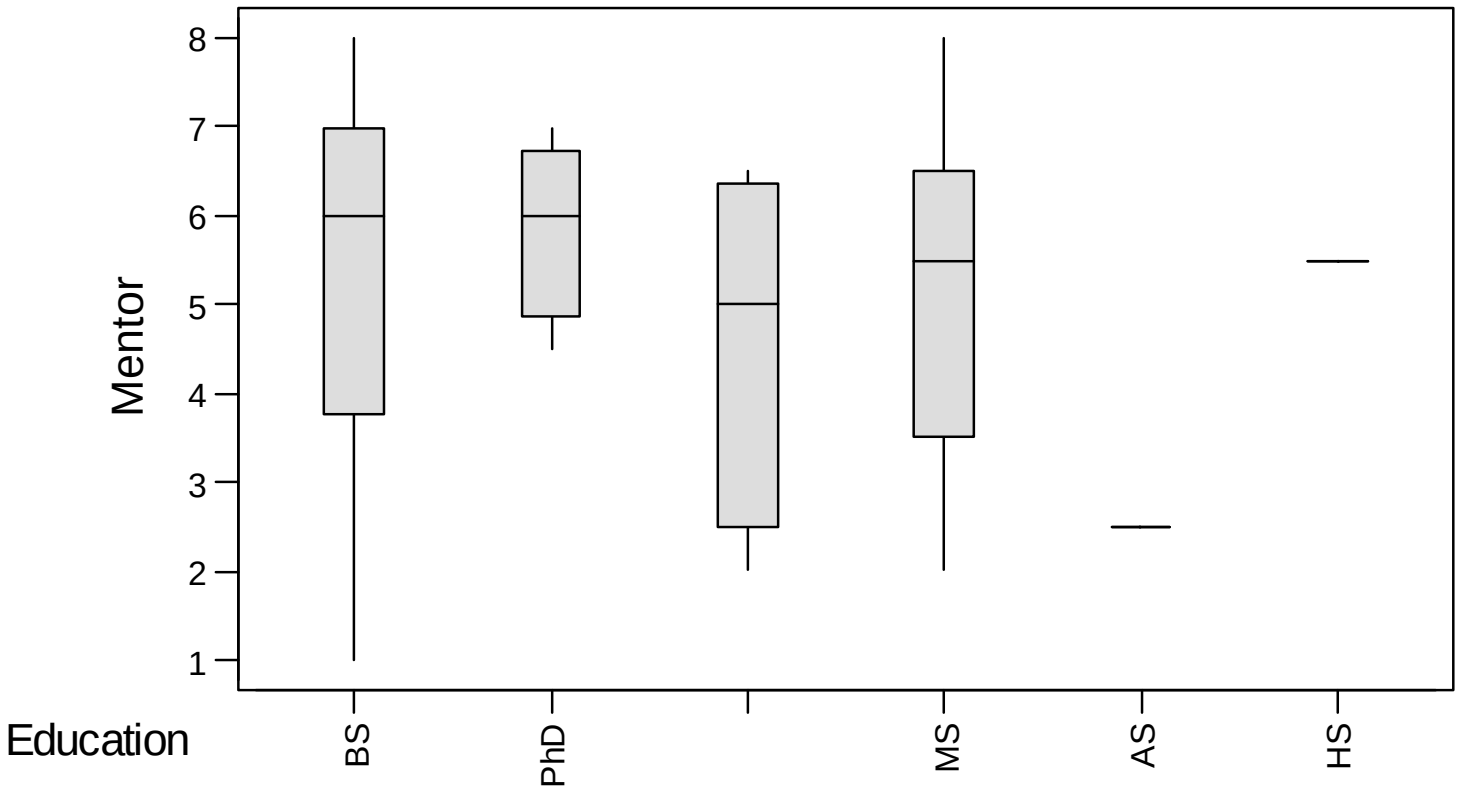
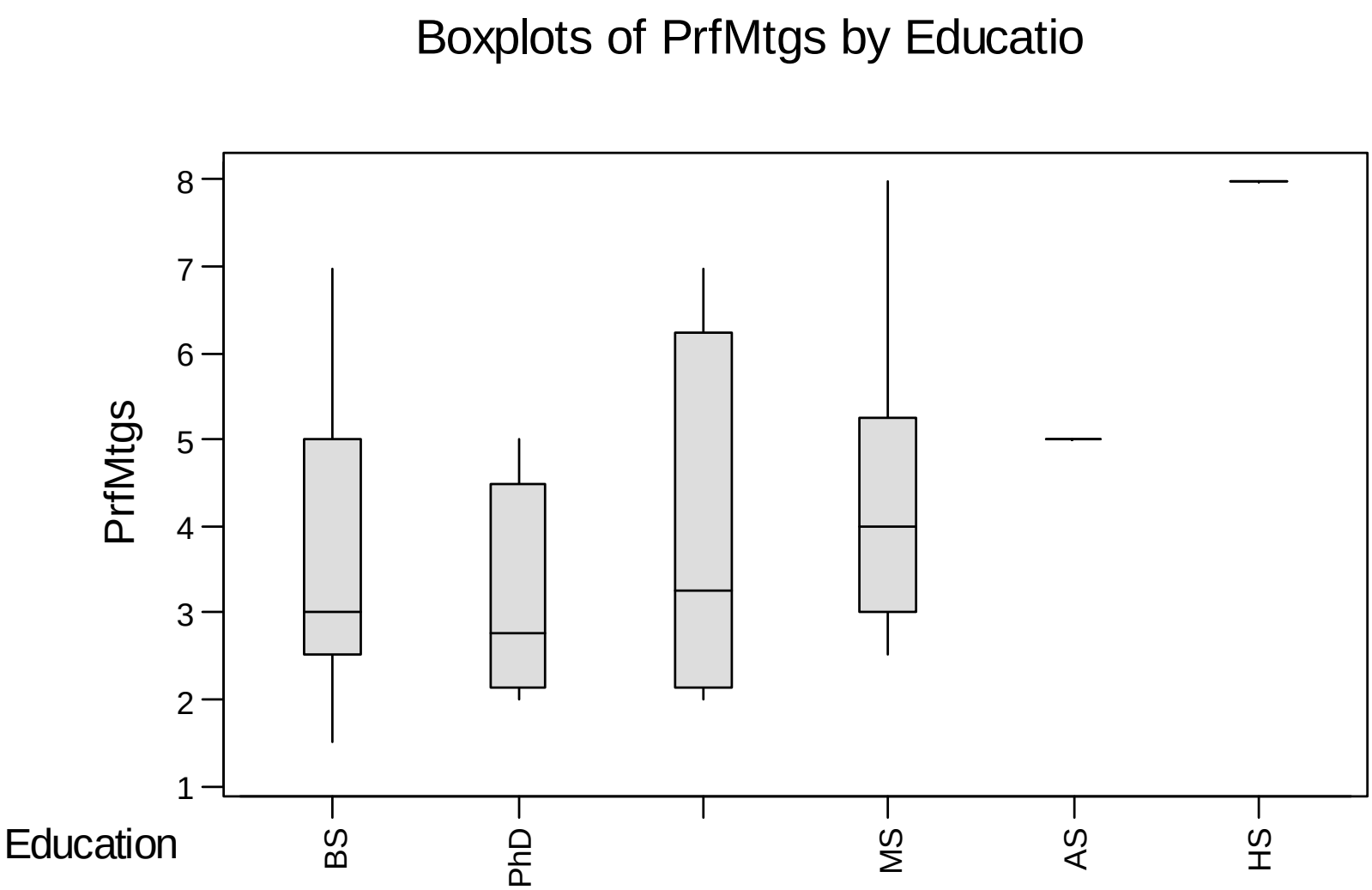
1
Education
BS
PhD
MS
AS
HS

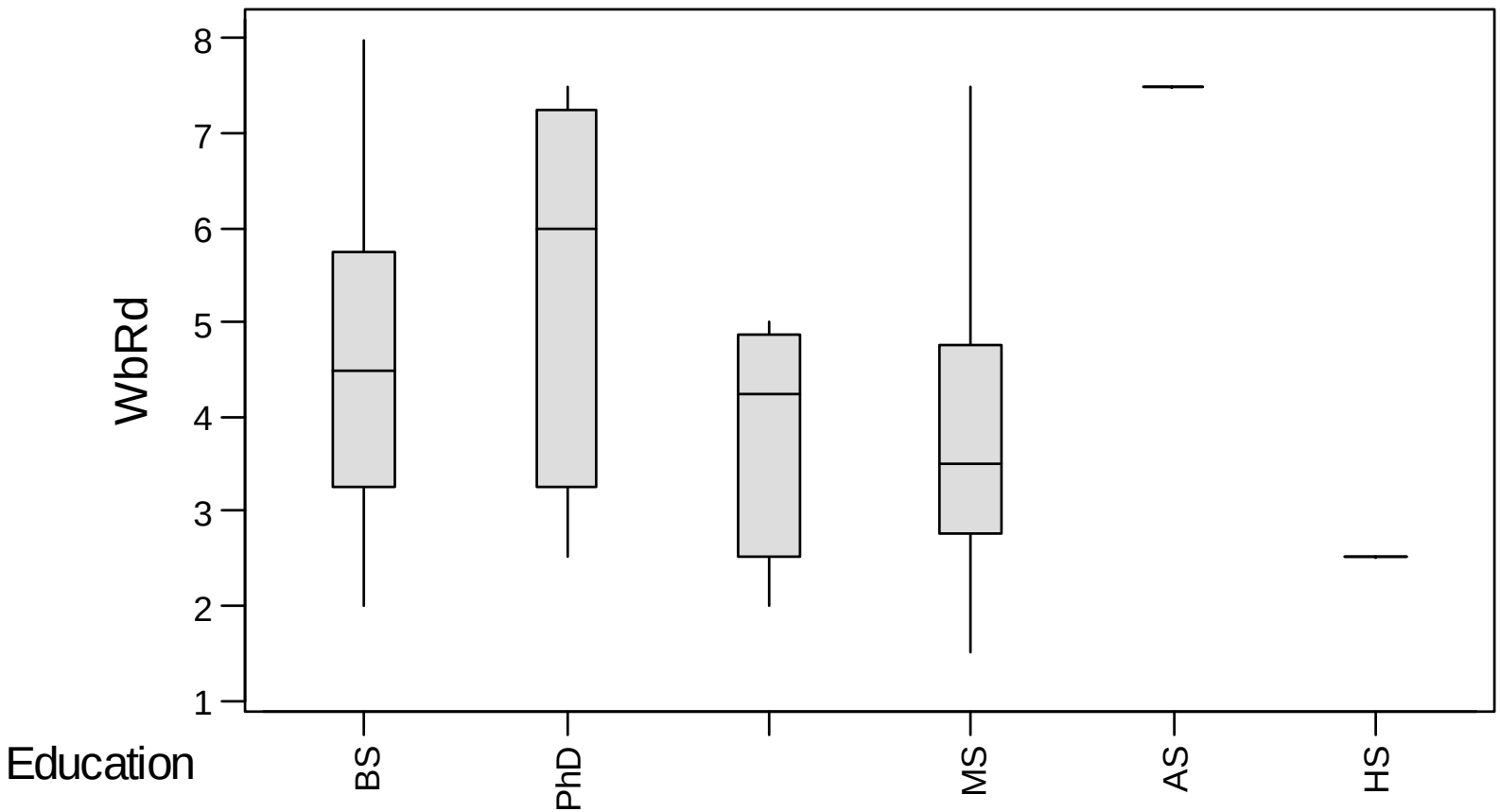
Certification By Education



Mentors by Education




Boxplots of PrfMtgs by Educatio
PrfMtgs
8
7
6
5
4
3
2
1
Education
BS
PhD
MS
AS
HS


Boxplots of WbRd by Educatio
WbRd
8
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4
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2
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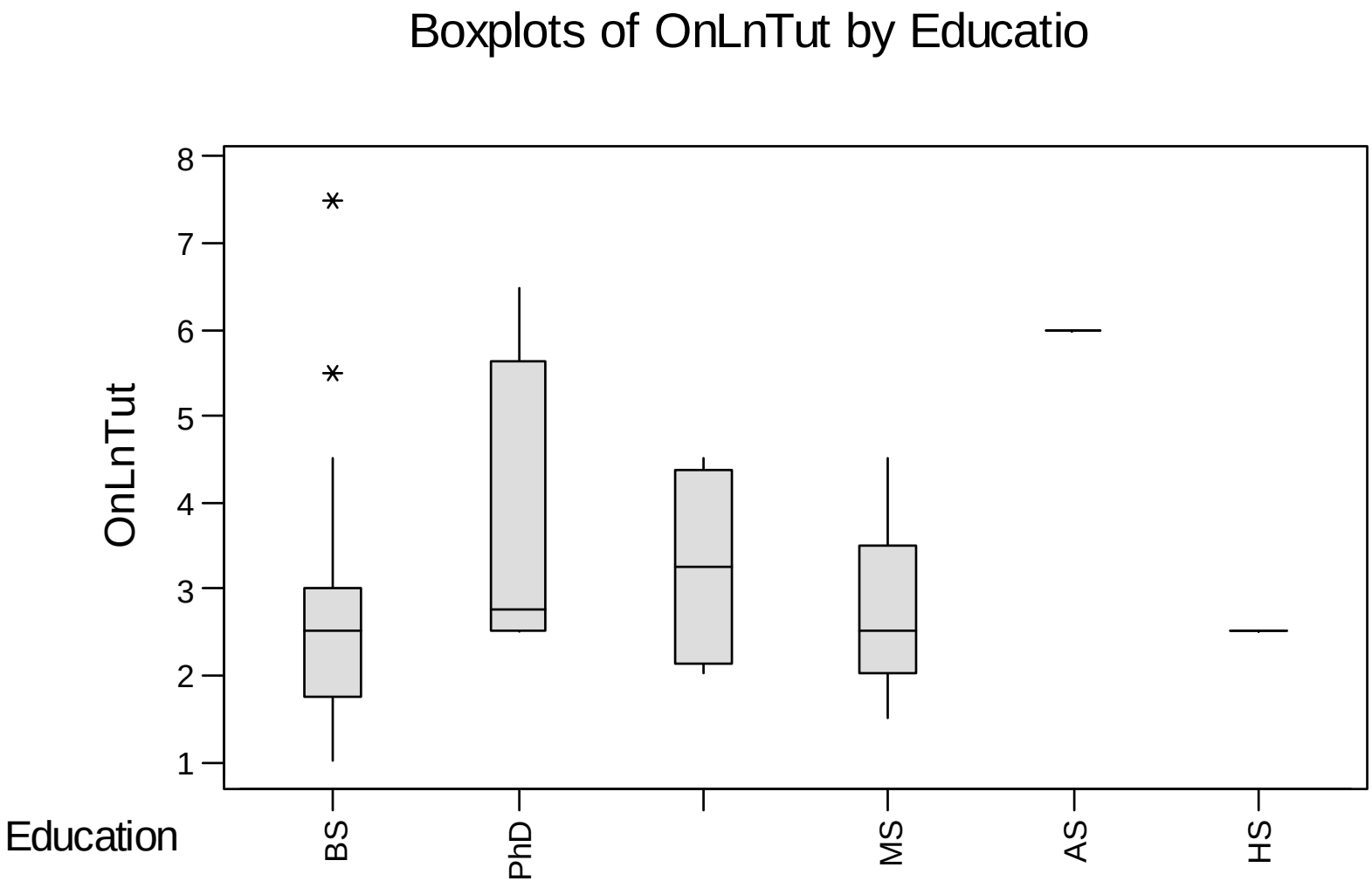
Education
BS
PhD
MS
AS
HS


Boxplots of OnLnTut by Educatio
OnLnTut
8
7
6
5
4
3
2
1
Education
BS
PhD
MS
AS
HS

Conclusions

- Survey is a First Attempt and Pilot Study
- Heavily Industrial/Chemical Engineers
- Validates the two problem statements:
  - Not enough stats taught during college
  - Need for post-college self-study material
- Shows percentages of preferred methods:
  - Readings, certifications, courses, mentors
- Further work on going:
  - Please fill the Survey Form!!!