A Survey on Ways Engineers Learn Statistics After Leaving College

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Abstract

This is the first of a three-part work on how engineers learn statistics after leaving college. Here we present a survey of practicing engineers, undertaken to support the tenants of the main paper, presented at ICOTS-7 in Brazil. We discuss the sample taken, its composition and the questions and answers elicited in the survey. Finally, we present the main survey results

Keywords: Statistics education, surveys, data analysis

1. Introduction

Two years ago this author was invited to write a paper on statistical education for the ICOTS-7 (International Conference on Teaching Statistics), Salvador, Brazil. We chose the topic of how engineers learn statistics after leaving college, an area where we have worked for over twenty five years (Romeu, 1986).

However, we soon discovered in our literature search that statisticians had studied how all cohorts studied statistics, from pre-school children to college graduate students. But there was no research on how practicing engineers approached this problem.

In our ICOTS-7 peer-reviewed paper (Romeu, 2006a), we proposed two main hypotheses that we needed to support. Given the lack of previous research on the topic, we decided to investigate this empirically, via a survey of practicing engineers. Such survey would assess whether engineers (1) acquired enough statistics in their college studies and (2) whether they studied it, after college, on their own, as best they could (and what means they actually used to learn it).

This survey was taken among American engineers and its results supported our research hypotheses. In a third paper, presented at the 2006 ASA/JSM in Seattle, we presented the survey results analyses (Romeu, 2006b)

We knew, from our many years teaching statistics in engineering departments as well as in short courses for industry, that college training fell short, and that many engineers needed substantially more statistics to be able to do their work. We wanted to assess how they were able to bridge the gap between their scant initial statistical training, and their professional needs.

This important problem has two serious components: one is educational and the other is social. Educational because there is no more room for additional statistics in the engineering curriculum. Hence, the solution has to be to move things up and down stream. Teach more statistics in grade and high school; then teach thinking in college so that the engineer may be able to learn as needed, later, on their own. Finally, to develop better tutorials and support materials for engineer use, during their lifelong learning process. The social component stems from an institutional paralysis (Romeu, 2006c).

In the rest of this paper, we will discuss how our survey was taken, describe its components, and how they were filled, and overview its main results

2. The Survey Input

In order to support our two working hypothesis, that the statistical education of engineers is deficient and inadequate, requiring engineers to learn statistics on their own at a later date (and further investigate the specific efforts they made to solve this need, we implemented a pilot survey. In our questionnaire (see ***http://web.syr.edu/~jlromeu/SurveyICOTS.html***) we asked, to characterize survey takers, several questions about the practicing engineer's personal background. We requested their education level (associate bachelor, masters or doctorate), area (academe, industry or government), specialization (mechanical, electrical, industrial, etc.), total number of statistics courses they had taken in college, years practicing engineering, country where they practiced (an overwhelming majority were from the USA) and gender.

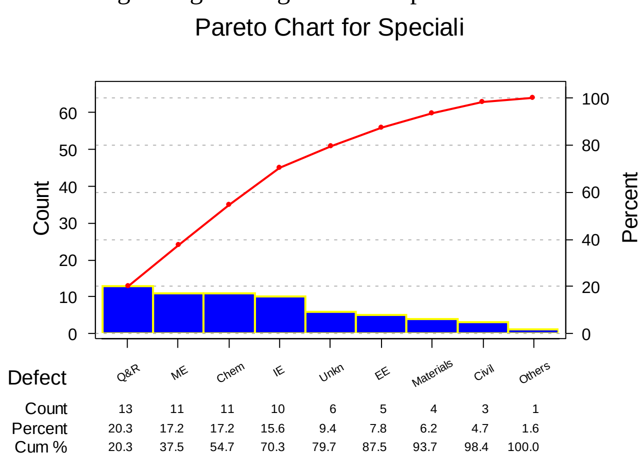
Then, we asked how they had acquired their post-college statistical knowledge on their own: (1) reading books, journals, manuals or other hard copy materials, (2) reading Web and Internet materials and tutorials, (3) following on-line courses or learning software, (4) attending symposiums, conferences chapter meetings, talks, etc., (5) pursuing preparation for professional certifications such as American Society for Quality, (6) taking internal company or commercial short training courses, (7) receiving mentoring from other, more experienced work colleagues and (8) any other sources, such as hands-on (or practical) working experiences (here many survey takers specified having received Six Sigma training courses).

The survey was submitted to the members of several quality, reliability, manufacturing, etc., engineering chapters in Central New York (CNY) and to many mid-career consultants, via our teaching of reliability courses to the annual engineering TACNY conference Through the ISOSTAT group, we were able to tap engineers from a pharmaceutical company in Florida. Finally, the survey was also taken by a handful of European engineers, thanks to newsletter promotions graciouly provided by the ASQ, the RSS and ENBIS international professional societies.

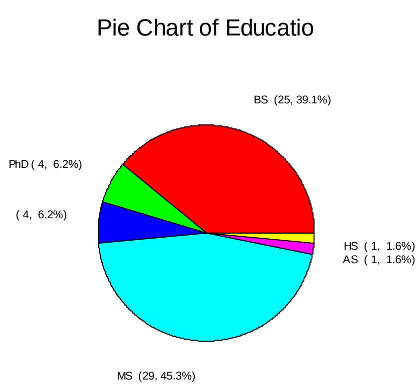
Our sample characterization is the following:

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

According to engineering technical specialization:



And according to engineering educational level:



Our sample was not randomly, nor scientifically drawn from a sampling frame (such frame does not exist), nor we claim it was. But, for a pilot effort and given that a sample size of sixty plus individuals responded, at the time we presented the paper, we believe it will provide interesting, valid, initial information for further study.

3. The Survey Results

To each survey taker we asked to provide, in rounded percentages, their assessment of the amount of post college statistical knowledge they had acquired, by each of the eight categories. For example, say an engineer thought they had acquired half of their statistics knowledge by reading books and other hard copy materials, and the other half, by equal parts, via short courses and mentoring. Then, this engineer would fill the entry “hard copy” with 50, and the entries “short courses” and “mentoring” with 25 each. In every case, the percentages had to add to 100.

The survey data collected so far (we are still receiving information) yielded the following results regarding our working hypotheses:

A) College 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.

B) 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%).

The descriptive statistics for the variables are:

Parametric Confidence Intervals

Variable	N	Mean	StDev	95.0 % CI
HardRead	64	26.08	24.31	(20.00, 32.15)
WebRead	64	9.58	13.22	(6.28, 12.88)
OnLnTuto	64	2.016	4.682	(0.846, 3.185)
ProfMtgs	64	6.43	9.74	(4.00, 8.86)
Certific	64	12.47	18.44	(7.86, 17.08)
ShortCou	64	12.15	16.05	(8.14, 16.16)
Mentorin	64	14.41	14.58	(10.76, 18.05)
OtherWay	64	15.47	24.19	(9.43, 21.51)
StatCour	51	1.725	1.686	(1.251, 2.200)
YrsPract	55	18.93	10.80	(16.01, 21.85)

If we are not willing to make assumptions about the Normality or symmetry of the data and prefer to work with non-parametric estimators, we have:

Wilcoxon Signed Rank Confidence Interval

	N	Estimat. Median	Confidence	Interval
HardRead	64	0	95.0	(15.0, 30.0)
WebRead	64	0	95.0	(5.00,10.00)
OnLnTuto	64	0	95.0	(0.00, 2.50)
ProfMtgs	64	0	95.0	(2.50, 6.50)
Certific	64	0	95.0	(5.0, 15.0)
ShortCou	64	0	95.0	(5.0, 15.0)
Mentorin	64	0	95.0	(10.0, 15.0)
OtherWay	64	0	95.0	(5.0, 17.5)
StatCour	51	1	95.0	(1.00, 2.00)
YearsPra	55	9	95.0	(15.5, 22.5)

We then converted the survey results from percentages to ranks. For example, in the previous case of filling an entry, we assumed that the engineer had most learned via reading hard copy, then equally via short courses and mentoring, and finally, least via all other means up to the eight that we had included in our survey. Hence, hard copy would get a rank of 8 (Highest rank being the most preferred), short courses and mentoring would tie for ranks 6.5 and all other means would tie for ranks 2.5 each (as they were 1 through 5). The statistical analysis of such rank data yielded:

Sign CI for median of rank data:

	N	Median	Conf.	CI.
HrdRd	64	6.00	0.939	(5.5, 7.0)
WbRd	64	4.00	0.939	(3.5, 4.5)
OnLnTut	64	2.50	0.939	(2.5, 3.0)
PrfMtgs	64	3.50	0.939	(3.0, 4.5)
Certif	64	4.00	0.939	(3.0, 5.5)
ShrtCrs	64	4.75	0.939	(3.5, 5.5)
Mentor	64	6.00	0.939	(4.5, 6.0)
OthrWys	64	3.50	0.939	(3.0, 4.5)

We can observe how in all three cases, the ranking of the variables is consistently maintained and supports the findings reported above.

4. Survey Conclusions

The present pilot survey was taken mainly from industrial, manufacturing, reliability, quality and such. We compare it with the total US national percentages:

Specialty	***Actual***	**Survey**
Total, All Engineers	100	100
Electrical & Electronics	24	9.4
Mech&Aero	19	17.2
Civil	13	4.7
Industrial	9	15.6
Chemical	3	17.2
Materials	1	6.2
All Other	31	29.7

The sample is still large enough that its results provide general trends for further study. They also support both of our working hypotheses: that engineers take very little statistics in college and that they have to learn on their own. Finally, the survey shows the actual means that engineers use in their learning process.

Acknowledgements

We thank our colleagues in the various professional organizations: of CNY, ENBIS, RSS, ASA and ASQ, and the newsletter editors that helped us advertise this survey, and all the engineers who volunteered to fill it.

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