Defining the process for measuring the student outcome "i" of ABET in the Industrial & Mechanical Engineering Department

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Abstract

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Key words

ABET, student outcome, continuous improvement

1. Background

The Industrial Engineering Program at UDLAP is accredited by ABET. One of requirements for the accreditation is to assess and evaluate the student's outcomes ("a" to "k"). The student outcome "i" says that graduates will demonstrate recognition of the need for, and an ability to engage in life-long learning.
Beyond the ABET criteria, "in many industries and countries, the most in-demand occupation or specialties did not exist 10 or even five years ago, and the pace of change is set to accelerate. By one popular estimate, 65% of children entering primary school today will ultimately end up working in completely new job types that don't yet exist[1]". Therefore the relevance of enhancing this outcome.

2. Methodology

2.1 Original approach

The Industrial & Mechanical Engineering Department of UDLAP defined a proposal of process for measuring how many students meet the minimum score (Figure 1).

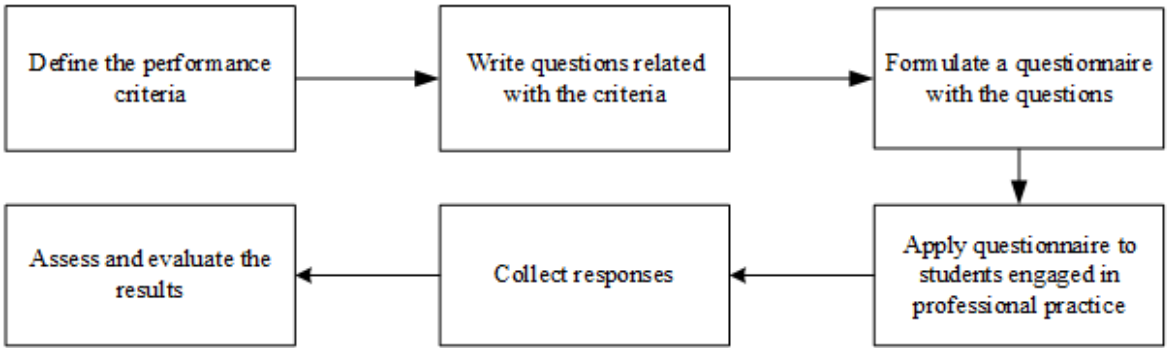

Figure 1: Process for measuring the number of students that meet the minimum score

[1] McLeod, Scott and Karls Fisch, "Shift Happens", https://shifthappens.wikispaces.com by "The Future of Jobs Report" of WEF, 2016

Novice	Apprentice	Proficient	Exemplary
1	2	3	4

Table 1: Score scale for the performance criteria

The score scale is showed in Table 1; the minimum score is 3.

The ABET student outcomes are eleven but in this document the analysis is only for the student outcome "i": Graduates will demonstrate recognition of the need for, and an ability to engage in life-long learning.

First and second steps: define the performance criteria and write questions related with the criteria

Performance criteria	Question
1) Awareness of the existence of professional associations in the field of engineering that correspond.	How level you rank your knowledge about the professional associations of your field of engineering?
2) Awareness of the existence of professional certifications available for the field of engineering that correspond.	How level you rank your knowledge about the professional certifications of your field of engineering?
3) Recognition of future need in the profession.	How level you rank your knowledge about the future needs of your field of engineering?
4) Recognition of options to engage in graduate studies in the field of engineering that correspond.	How level you rank your knowledge about graduate studies of your field of engineering?
5) Ability for self-learning.	How level you rank your ability for self-learning?

Table 2: Performance criteria and questions

Third step: Formulate a questionnaire with the questions

The questionnaire included questions related with the eleven student outcomes; the introduction of the questionnaire required the student supposes that he/she was hired for a company in order to integrate a team work for developing certain engineering project. The questionnaire had sixteen items and for each one the student should select a "value" according to the guidelines showed in Table 3.

Level	0-25%	26-50%	51-75%	76-100%
Value	1	2	3	4

Table 3: Scale for self-assessment

The section of the questionnaire related with the student outcome "i" is deployed in Figure 2.

Student outcome	Question	Value (1, 2, 3, 4)
i	How level you rank your knowledge about the professional associations of your field of engineering?	
	How level you rank your knowledge about the professional certifications of your field of engineering?	
	How level you rank your knowledge about the future needs of your field of engineering?	
	How level you rank your knowledge about graduate studies of your field of engineering?	

	How level you rank your ability for self-learning?	

Fourth step: Apply questionnaire to students engaged in professional practice

On spring 2017 twenty-one students responded the questionnaire.

Table 1 contains the percent of students that rank selves at high level (75-100%):

Table 2

Question	Industrial Engineering	Logistics Engineering	Mechanical Engineering
a	50%	67%	43%
b	40%	33%	57%
c	70%	33%	43%
d	50%	33%	71%
e	100%	67%	100%

Because of the interest for evaluating the variability of the responses, there were the aim in using a control chart. Pyzdek[2] suggests an approach for selecting the proper control chart for a particular data set. This approach is illustrated in figure 1

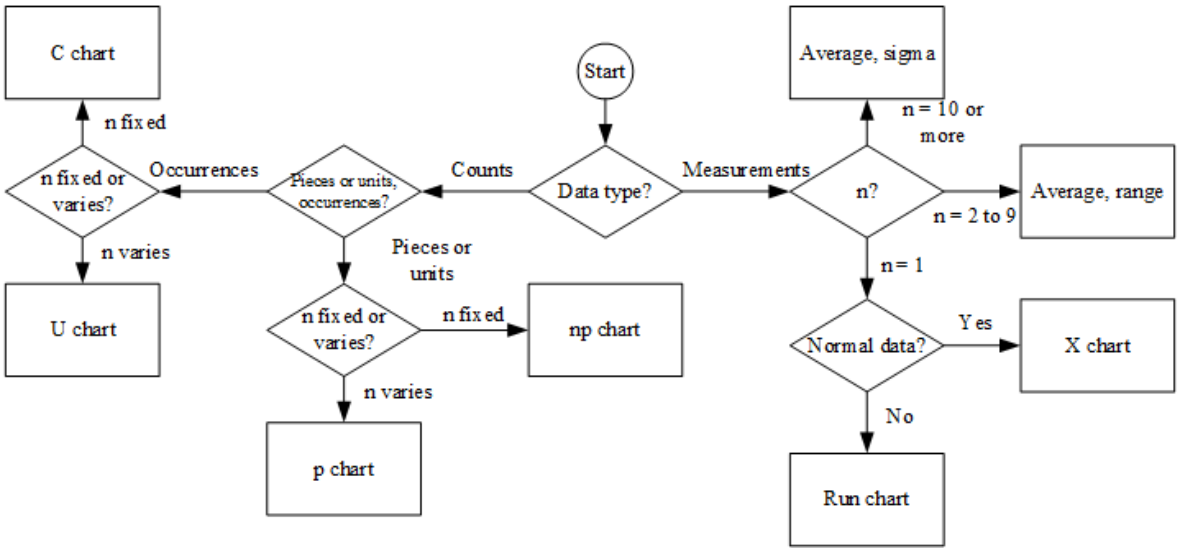

Figure 1: Control chart selection flow diagram

Firstly, the analysis data will be the set of answers of each question. For example, the twenty answers to the question "a" were:

Table 2

Student	1	2	3	4	5	6	7	8	9	10
Response	4	3	4	2	4	3	3	3	4	4
Student	11	12	13	14	15	16	17	18	19	20
Response	4	3	4	4	3	2	4	3	3	4

The data type is "measurements" and n = 1. Therefore, the next question is: the data has a normal distribution? Using Minitab software, it will be evaluate the data; specifically by means of a normality test. The Minitab tool evaluates the null hypothesis (H_o) that the data follow a normal distribution. If the p-value for the test is less

[2] "The Six Sigma Handbook", page 419

than the chosen α-level, then the H_o must be rejected and conclude that the data do not follow a normal distribution. The normality test was executed with Kolmogorov-Smirnov method using α-level equals to 0.15. The output of the analysis contained in figure 3 demonstrates that the null hypothesis must be rejected; that means that the data do not follow a normal distribution. Then a run chart could be used; but this type of chart runs effectively with ordinal data? An ordinal variable is one that has two or more categories and these are clearly ordered.

Pyzdek[3] writes: "run charts should be used for preliminary analysis of any data measured on a continuous scale that can be organized in time sequence"; the rank self-evaluated by the students is not measured on a continuous scale but on a discrete scale. Then the run-chart won´t be used for the variability analysis.

Wardell and Candia (1996) suggest a tool for monitoring of customer satisfaction survey data. Because of the data are obtained from a discrete scale, the tool will be used for analyzing the ranks.

Table 3

k	Number of responses	p_x
1	0	0.0
2	2	0.1
3	8	0.4
4	10	0.5

The control limits are defined so (n=1):

$$\sum_{x=1}^{k} xp_x \pm \frac{3}{\sqrt{n}} \sqrt{\sum_{x=1}^{k} x^2 p_x - \left(\sum_{x=1}^{k} xp_x\right)^2}$$

$\sum_{x=1}^{k} xp_x = (1 \times 0.0) + (2 \times 0.1) + (3 \times 0.4) + (4 \times 0.5) = 3.4$

$\sum_{x=1}^{k} x^2 p_x = (1^2 \times 0.0) + (2^2 \times 0.1) + (3^2 \times 0.4) + (4^2 \times 0.5) = 12$

$LCL = 3.4 - 3 \times (12 - (3.4)^2)^{1/2} = 1.41 \approx 2$

$UCL = 3.4 + 3 \times (12 - (3.4)^2)^{1/2} = 5.38 \approx 5$

No one of data exceed the control limits; that means: there are not special causes of variation.

[3] "The Six Sigma Handbook", page 362

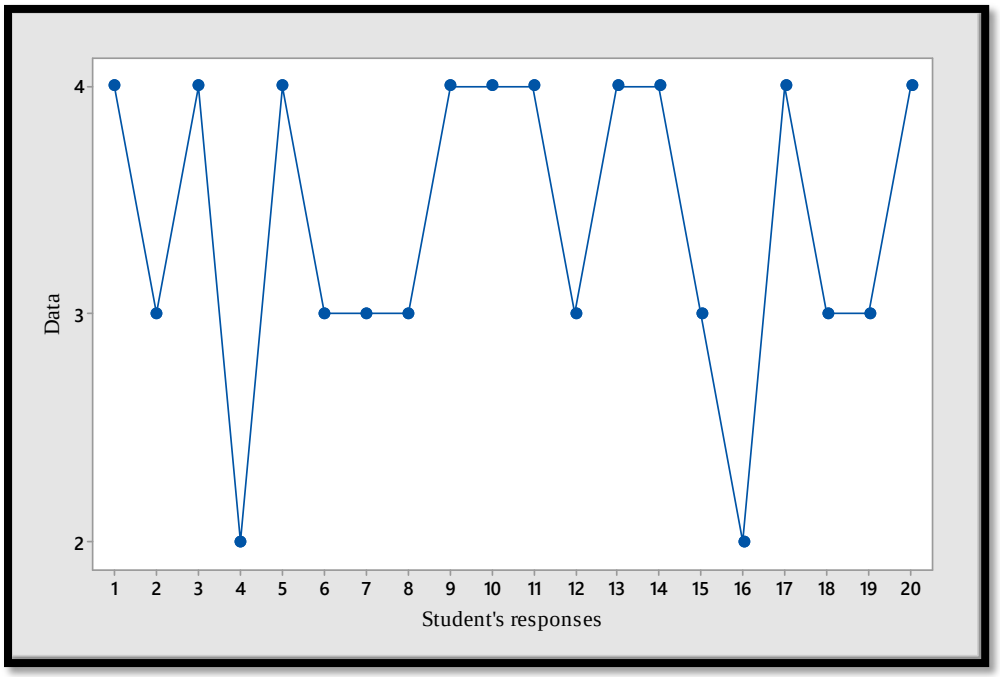

Figure 2: line plot of responses to question 1

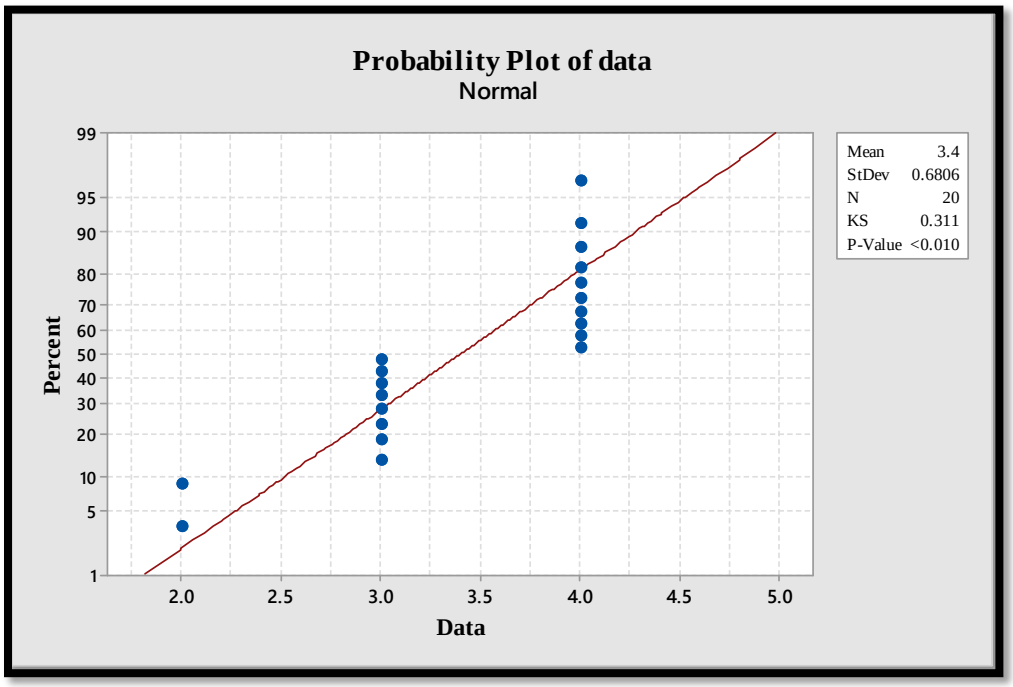

Figure 3: Normality test for the first set of data

However, the tool introduced Wardell and Candia is used with n > 1 and the former analysis was conducted with n = 1. Therefore, additional analysis is required. Figure 4 displays descriptive statistics of the responses to question 1. X is a random variable that represents the response to the question, then X = 1, 2, 3, 4. Because of the random variable is discrete the confidence interval for median will be used for analyzing the data. Two of the twenty responses for question 1 were outside the confidence interval. That could be caused by a special cause of variation.

A confidence interval for median will be obtained for the responses to the other questions.

Table 4

Question	Confidence interval for median	Number of responses outside the confidence interval
1	3, 4	2
2	3, 4	2
3	3, 4	1
4	3, 4	3
5	4, 4	1

The results could be interpreted as an evidence of existing of special cause of variation.

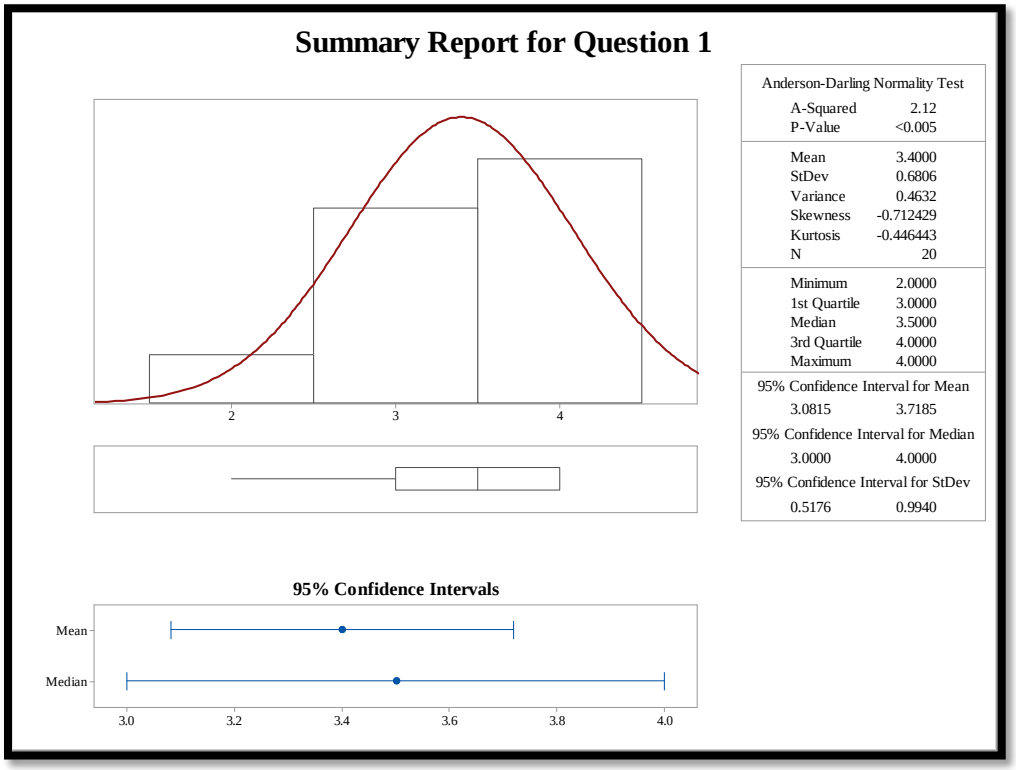

Figure 4: Summary report for question 1

What means “there is a special cause of variation” in this analysis? What process is being analyzed? The SIPOC diagram in figure 5 represents this process.

S	I	P	O	C
High Schools	Student (with an entry profile)	Develop the “student outcomes”	Student (with an exit profile)	Employer

Figure 5

Actually there is not an explicit process for developing the “student outcomes”; students are exposed to diverse learning experiences and therefore the outcomes are unpredictable. However, this conclusion is known. The approach of this study isn’t to design a process for developing the “student outcomes” but to define a measure

process in order to establish a baseline. The figures contained in Table 1, should it be the initial reference? No, because of the process if out of control and the special causes of variation are unknown.

A new approach for measuring how extension this outcome is achieved was applied. During the spring and summer periods of year 2018, a survey was applied to the students engaged in professional practice. The questions of the survey were about specific subjects, not to know the perception but the knowledge of the students about the need to engage in life-long learning.

Table 5

Performance criteria	Questions
Awareness of the existence of professional associations in the field of engineering that corresponds.	**Q1:** Do you belong to a professional association in your field of engineering? Write the name of the association. Do you participate actively in this association?
	Q2: Write the name of professional associations that you know, in your field of engineering.
Awareness of the existence of professional certifications available for the field of engineering that corresponds.	**Q3:** Have you get any professional certification in your field of engineering? Write the name of the certification.
	Q4: Write the name of professional certifications that you know, in your field of engineering.
Recognition of future need in the profession.	**Q5:** Write the knowledge and skills in your field of engineering that you believe that you need to develop in order to strength your professional profile.
Recognition of options to engage in graduate studies in the field of engineering that corresponds.	**Q6:** Have you started the admission process to any graduate studies in your field of engineering?
	Q7: Write the name of graduate studies in your field of engineering; it's better if you write the full name of the graduate studies and the host university.
Ability for self-learning.	**Q8:** Describe briefly one or more problems that you solved with knowledge or skills achieved by "self-learning".

The survey was applied using the tool *Microsoft Forms* by Office 365© and the participation was mandatory for all students registered in the control course "Professional Practices". That means the survey was answered by the students without supervision of any member of the faculty.

3. Findings and analysis

The answers were collected during April, May, June and July of 2018. The Head of Industrial & Mechanical Engineering Department manage three undergraduate academic programs: Industrial Engineering, Mechanical Engineering and Logistics Engineering. Thirty and nine students of these programs submitted their responses using Microsoft Forms. The colleague that leads the control course of professional practices weekly sent them a message asking for the responses.

Responses collected (April, May and June; 2018)

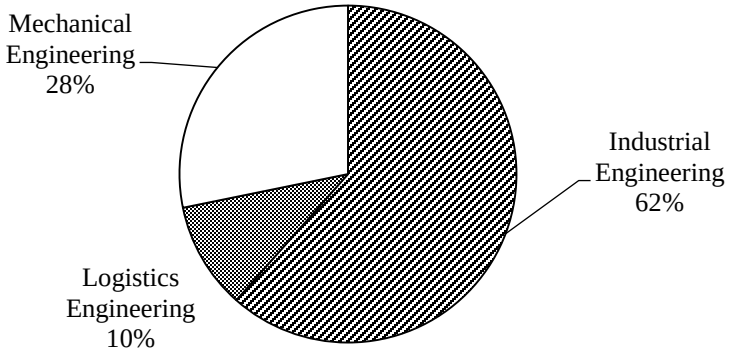

Figure 6

Criteria performance 1: Awareness of the existence of professional associations in the field of engineering that corresponds.
Question 1: Do you belong to a professional association in your field of engineering?

Table 6

Academic Program	Yes	No	Yes (But the association cited in the answer doesn't exist)	
Industrial Engineering	0	23	1	24
Logistics Engineering	0	4	0	4
Mechanical Engineering	0	8	3	11
	0	35	4	39

Question 2: Write the name of professional associations that you know, in your field of engineering.

Table 7

Academic Program	The student wrote an answer and the association cited in it exists	The student wrote an answer but the association cited in it doesn't exist	The student didn't write an answer	
Industrial Engineering	12	7	5	24
Logistics Engineering	2	1	1	4
Mechanical Engineering	1	8	2	11
	15	16	8	39

Criteria performance 2: Awareness of the existence of professional certifications available for the field of engineering that corresponds.

Question 3: Have you get any professional certification in your field of engineering? Write the name of the certification

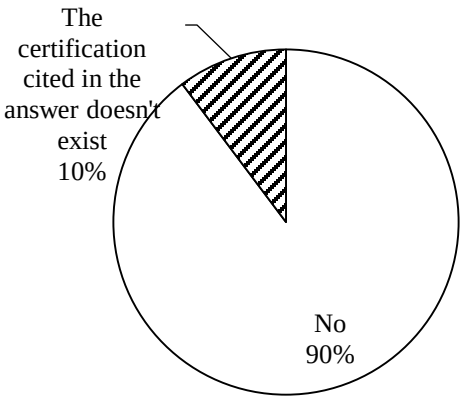

Figure 7

Question 4: Write the name of professional certifications that you know, in your field of engineering.

Table 8

Academic Program	The student wrote an answer and the certification cited in it exists	The student wrote an answer but the certification cited in it doesn't exist	The student didn't write an answer	
Industrial Engineering	18	0	6	24
Logistics Engineering	2	0	2	4
Mechanical Engineering	2	2	7	11
	22	2	15	39

Criteria performance 3: Recognition of future need in the profession.
Question 5: Write the knowledge and skills in your field of engineering that you believe that you need to develop in order to strength your professional profile

Table 9

Academic Program	The student wrote a sentence with a knowledge or skill that is taught in a course of her/his curriculum	The student wrote a sentence with a knowledge or skill that isn´t taught in a course of her/his curriculum	The student wrote a sentence with a soft skill	The student wrote a sentence without any knowledge or skill	
Industrial Engineering	11	5	5	3	24
Logistics Engineering	1	2	1	0	4
Mechanical Engineering	5	1	5	0	11
	17	8	11	3	39

Nobody responded with a sentence that included a knowledge or skill that should be acquired to face the challenges of the current technological race.

Criteria performance 4: Recognition of options to engage in graduate studies in the field of engineering that corresponds.
Question 6: Have you started the admission process to any graduate studies in your field of engineering?

Table 10

Academic Program	The student has started the admission process to enter graduate studies in her/his field of engineering	The student has started the admission process to enter graduate studies different of her/his field of engineering	The student hasn't started the admission process to enter graduate studies	
Industrial Engineering	1	2	21	24
Logistics Engineering	0	1	3	4
Mechanical Engineering	0	1	10	11
	1	4	34	39

Question 7: Write the name of graduate studies in your field of engineering; it's better if you write the full name of the graduate studies and the host university.

Table 11

Academic Program	The student wrote a sentence with full information about graduate studies in her/his field of engineering	The student wrote a sentence with partial information about graduate studies in her/his field of engineering	The student wrote a sentence with information about graduate studies different of her/his field of engineering	The student did not write a sentence with information about graduate studies	
Industrial Engineering	6	4	5	9	24
Logistics Engineering	1	0	2	1	4
Mechanical Engineering	2	3	1	5	11
	9	7	8	15	39

Criteria performance 5: Ability for self-learning.

Question 8: Describe briefly one or more problems that you solved with knowledge or skills achieved by "self-learning"

Table 12

Academic Program	The student wrote a sentence with a technical knowledge or skill achieved by "self-learning"	The student wrote a sentence with a "soft skill" achieved by "self-learning"	The student wrote a sentence with a knowledge or skill that is taught in a course of her/his curriculum	The student wrote a sentence without any knowledge or skill achieved by "self-learning"	
Industrial Engineering	6	3	3	12	24
Logistics Engineering	1	0	2	1	4
Mechanical Engineering	5	1	0	5	11
	12	4	5	18	39

X. References

Pyzdek, T (2003), *The Six Sigma Handbook*, USA: McGraw-Hill

Y. Appendix A