Investigating the impact of offering Statistics on students success

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Abstract

This article describes the author's experience in developing and teaching an undergraduate course on Statistics for Industrial Engineering Technology (IET) students. Moreover, the impact of offering the course on students' success in future courses for which Statistics is a pre-requisite, is discussed. The motivation to offer the course is twofold: 1) Statistics is a subject required by various programs and although several sections are being offered, often IET students would not be able to register in the course and consequently, they have to wait for next semester. 2) Since the Mathematics Department caters to students coming from various majors, the topics and particularly, examples and problems would not be necessarily major-oriented. In addition, the course has been offered since spring of 2012 and the degree to which the topics covered have addressed students need and faculty expectation are unknown.

In this article, the author first describes the details of how the course was developed, how it would address relevant ABET's accreditation criteria, and how it has been taught since spring of 2012 in terms contents. Then, the results of inquiry from faculty members in the department, as well as a summary of the course evaluations is presented. Finally, future modification to improve the course contents is mentioned.

Introduction

Statistics and probability play an important role in almost all engineering and engineering technology disciplines particularly, in industrial engineering technology. Students working in such fields as quality control, manufacturing engineering, and reliability should be familiar with statistics and probability and how to use them to improve and promote quality. In addition, the IET program is accredited by Accreditation Board for Engineering and Technology (ABET) which "is a nonprofit, non-governmental organization that accredits college and university programs in the disciplines of applied science, computing, engineering, and engineering technology." [1] The ABET's Criterion 3b suggests that students must have"an ability to design and conduct experiments, as well as to analyze and interpret data" [2].

Historically, the students who pursued a Bachelor of Science in Industrial Engineering Technology (IET) at Indiana University-Purdue University Fort Wayne (IPFW) took a course on statistics and probability, called STAT 301, offered by the Department of Mathematics. This course is a requirement for a majority of degree programs at the university. Often IET students weren't be able to register in the course, despite that various sections were offered every semester, because all the sections fill quickly and consequently, IET students had to wait for next semester to register which would mean that they could not take the technical courses for which statistics was a prerequisite.

This paper discusses the development and introduction of an in-house course, named Applied Statistics for Engineering Technology (IET 205), on statistics and probability in Industrial Engineering Technology program at IPFW.

Course development

IPFW is one of the joint regional campuses of Indiana University and Purdue University and therefore, all the degrees are offered by either of these two main universities. In case of Engineering Technology, the degrees are granted Purdue University degrees. The instructor contacted the regional campuses, as well as the main campus of Purdue University, where a baccalaureate degree in IET was being offered to learn about whether a similar course was being offered. In addition, the instructor contacted the faculty members of the IPFW's Department of Manufacturing and Construction Engineering Technology and Interior Design to seek their suggestions on what topic should be discussed in Statistics for engineering technology students and what their expectations are from those who would take the course. Based on this inquires, and considering ABET's criteria, the following objectives were developed:

- Learn about categorical and quantitative data.
- Display data and results of analyses in a meaningful manner.
- Learn measures of central tendency and dispersion
- Learn about regression analysis
- Understand the elements of probability and random numbers and their applications.
- Learn about normal distribution and its applications.
- Understand statistical inferences, hypothesis testing, and their applications
- Be able to work effectively in teams to complete a project on the application of Statistics
- Be able to apply the lessons learned, present the findings of the group project in an oral presentation, and response to audience questioning.

In addition, the course (IET 205) was approved later on to be included in General Education category so other non-technical majors could take it. It meets the following requirements under the university's General Education's Categories A.3 (Foundational Intellectual Skill, Quantitative Reasoning) [3]:

3.1 Interpret information that has been presented in mathematical form (e.g. with functions, equations, graphs, diagrams, tables, words, geometric figures).
3.2 Represent information/data in mathematical form as appropriate (e.g. with functions, equations, graphs, diagrams, tables, words, geometric figures).
3.3 Demonstrate skill in carrying out mathematical (e.g. algebraic, geometric, logical, statistical) procedures flexibly, accurately, and efficiently to solve problems.
3.4 Analyze mathematical arguments, determining whether stated conclusions can be inferred.
3.5 Communicate which assumptions have been made in the solution process.
3.6 Analyze mathematical results in order to determine the reasonableness of the solution.
3.7 Cite the limitations of the process where applicable.
3.8 Clearly explain the representation, solution, and interpretation of the math problem.

As far as ABET's criteria, Table 1 shows the details as to how each criterion is related to the course' objectives and how it would be assessed. For example, group projects would be used to

assess how students functioned and cooperated in a group. A list of ABET criteria is gathered in Appendix A.

Table 1. A summary of how course objectives would address University and ABET criteria.

Topics	**Method**	**General Education Criteria**	**ABET Criteria**
Learn about categorical and quantitative data	Assignments, Exams, Group Project	3.1 – 3.8	a, k2
Display data and results of analysis in a meaningful manner	Assignments, Exams, Group Project	3.1 – 3.8	a, b, f, k2
Learn measures of central tendency and dispersion	Assignments, Exams, Group Project	3.1 – 3.8	a, b, f, k2
Learn about regression analysis	Assignments, Exams, Group Project	3.1 – 3.8	b, f, k2
Understand the elements of probability and random numbers and their applications	Assignments, Exams, Group Project	3.1 – 3.8	a, b, k2
Learn about normal distribution and its applications	Assignments, Exams, Group Project	3.1 – 3.8	a, b, f, k2
Understand statistical inferences, hypothesis testing, and their applications	Assignments, Exams, Group Project	3.1 – 3.8	a, b, f, k2
Be able to work effectively in a group project	Group Project	3.5, 3.7, 3.8	d, e, g1, g2, k2
Be able to apply the lessons, learned, present the findings of the group project in an oral presentation, and response to audience questions	Group Project	3.5, 3.7, 3.8	d, e, g1, g2, k2

Course requirements

The course includes several requirements; however, the author believes that the following requirements are more noteworthy:

1. Textbook(s)
   After reviewing the textbooks that were adopted by other campuses, the instructor chose Veaux,Velleman, and Bock's Intro Stats (by Pearson).[4]. The authors introduce concepts in an informal manner, often humorously, and explain the reasons and logic behind them before jumping into equations, which matches the instructor's approach in teaching. In addition, the examples and problems in this textbook are a reasonable mixture of technical and non-

technical ones which make it easier to find relevant problems for a technical field. The textbook has been used since the course is being introduced and the majority of students seem to be satisfied with it.

2. Term Project: Students are to work in groups on a term project of their choice. The emphasis is on studying a real world project (i.e., to solve a problem using the concepts learned in the course). Appendix B includes the group project criteria. By the end of the semester, each group presents the project and other students evaluate the project. Furthermore, each group member is to complete a peer evaluation form to evaluate other members in terms of their contribution to the project. Appendix C includes both peer evaluation and presentation evaluation forms.

3. Software: In the first semester that the course was offered, the instructor required MINITAB to be used to solve example problems and homework assignments. However, the instructor's main concern was whether students would grasp the statistical concepts (i.e., meaning, interpretation, appropriate application, etc.) well enough before using any software. Furthermore, one of the instructor's colleagues who visited the class in the first semester observed that students might be distracted when the course is being offered in a computer lab and therefore, if software is still a requirement, the issue of students' distraction should be addressed. Therefore, for future semester, the software requirement was dropped to avoid the distraction issue.

Feedbacks from students and instructors

Students filled out departmental course evaluation survey to provide their feedback on the course contents, the instructor, the textbook, and as such. Overall, the feedbacks have been positive. For example, in response to a question on the textbook used, students' evaluation indicated a rating of 2.98 out of 4.0. One commented that: "the textbook was easy to comprehend." Another aspect that the majority of students rated relatively high was the group project, although some students had concerned with the topic and their partners. Table 2 includes a summary of students' responses to the survey questions in 2013 and 2014 (the results of spring 2012 survey were not available; plus, the course was not offered in fall 2012.).

As mentioned earlier, IET 205 is a pre-requisite to two upper-level courses in the IET curriculum: Statistical Process Control (IET 454) and Manufacturing Simulation (IET 369). The instructor has taught IET 369 and IET 454 since the introduction of the Statistics course and he observed that students seemed to be familiar with the relevant statistical concepts covered in IET 205. For example, in IET 369, students were familiar with various probability distributions and therefore, the instructor did not need to review those extensively. For IET 545, however, it would be difficult, if not impossible, to attribute students' knowledge on Statistics to IET 205 merely. One of IET 454's pre-requisite is IET 204 (Techniques of Maintaining Quality) in which principles of quality, including statistical aspects are discussed. Therefore, students who take IET 454 would have already been exposed to Statistics.

Table 2. Students' responses to course evaluation (1: poor, 4: excellent).

Question	**Semester**			
	Spring 2013 (Enrollment: 21)	Summer 2013 (Enrollment : 7)	Spring 2014* (Enrollment : 7)	Fall 2014* (Enrollment : 21)
The class contents	3.14	3.42	2.71	2.52
The textbook	3.24	3.14	2.71	2.86
The relevance of Assignments/Homework to the course goals	3.33	3.42	3.0	2.76
The adequacy of exams, reports, etc. in measuring student's understanding of the subject	3.38	3.28	3.29	2.86
The course overall	3.19	3.42	2.86	2.71

*: the course was taught by a graduate student.

Conclusion

A description of the rationale for offering an in-house course on Statistics was presented followed by a description on how the course was developed and taught. Since its introduction in spring of 2012, the majority of students took advantage of taking this course. Students' feedback indicated that the majority of them are satisfied with the textbook, the course contents, and the group projects. For future improvement, one area is to include more relevant examples, especially for class discussion, so students would be better able to relate the lectures to real world examples. In addition, although the software requirement was dropped, students would benefit from learning an specialized software package such as MINITAB in solving statistical problems. Therefore, the author is planning to investigate the possibility of providing an introductory lecture on MINITAB and mandate its usage in group projects.

Reference

[1] ABET (2015). *About ABET* [Online]. Available: http://www.abet.org/about-abet/

[2] ABET (2015). *Criteria for Accrediting Engineering Technology Programs, 2015 – 2016* [Online]. Available: http://www.abet.org/etac-criteria-2015-2016/

[3] [2] IPFW (2014). *General Education Requirements* [Online]. Available: http://bulletin.ipfw.edu/content.php?catoid=33&navoid=861#Area_A

[4] Pearson higher education (2009). *Intro Stat.* (3rd. ed.). [Online]. Available: http://www.pearsonhighered.com/pearsonhigheredus/educator/product/products_detail.page?isbn=0321500458

Appendix A: Relevant Criteria of the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (TAC/ABET) Outcomes [2]

a: an appropriate mastery of the knowledge, techniques, skills and modern tools of IET.

b: an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology.

d: an ability to apply creativity in the design of systems, components or processes appropriate to the program objectives.

e: an ability to function effectively on teams.

f: an ability to identify, analyze and solve technical problems.

g1: an ability to communicate effectively in writing.

g2: an ability to communicate effectively in oral presentation.

k2: a commitment to timeliness.

Appendix B: the group project criteria

Introduction

Students are to work in groups on a project of their choice related to the application of Statistics in engineering technology. At the end of the semester, students will present their projects in the class (power point presentation) and also, will submit the final report (one presentation and one report per group). Each team member also, submits peer evaluation report, assessing his/her teammates' performance. The final reports should be in Word format (font 12, double-space, approximately 1200 words, proof read) and is fully cited. The IEEE style should be used for preparing the report. All the reports and the power point files will be submitted electronically on the due dates mentioned in the course outline. Each group will have 10 minutes to present.

MS Word Report should include:

The report should include:

1. Project Introduction,
2. Rationale why you selected this project. What is its importance and application?
3. Description of your methodology
4. Details of the calculations, graphs, charts, etc.
5. The findings and discussion
6. Suggestions and recommendation for implementation.

Deadline

1- You need to submit both the report and the power point files by the deadline in Blackboard.

2- Each student in the group will complete the peer evaluation form, which will be uploaded in Black Board by the deadline.

3- Students will print the group presentations evaluation form, which will be uploaded in Black Board, and bring it with them on the presentation days. At the end of the second presentation day, they will give their form to the instructor.

Grading

The total individual grade is the sum of the peer evaluations (30%), class evaluation (20%), and the instructor's evaluation (50%).

Appendix C: A sample of peer and presentation evaluation forms

Peer evaluation form

On scale 1 to 5, 5 being excellent and 1 being poor, please evaluate your colleagues as listed below:

Name	Collaboration	Communication	Timely delivery	Work Attitude	Overall evaluation

Comments:

Presentation evaluation form

On scale 1 to 5, 5 being excellent and 1 being poor, please evaluate the groups as listed below:

Group	Introduction, rationale, importance of the topic, etc.	Appropriate use of graphs	Use of statistical methods and tool in data analysis	Discussion, suggestions and recommendation.	Well-organized Presentation, Individual Involvement, Time Management	Presentation Style, Techniques, Punctuations, Grammar, etc.
1						
2						
3						
4						