Teaching Business Statistics by Examples: An Illustration, Benefits, and Challenges

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This study proposes the teaching-by-examples (TBE) approach where the learning objectives are achieved by creating lesson plans encompassing hands-on examples that take precedence in operationalizing the concepts and theories. It illustrates the TBE approach within the context of business statistics and proposes that there is a significant difference in the mean performance of students taught by the TBE approach and of those taught by the traditional lecture method. The findings suggest that the TBE approach results in better student performance than the traditional lecture method. This study also discusses the challenges that accompany the benefits of the TBE approach.

Keywords: teaching-by-examples approach, traditional lecture method, business statistics, ontology, epistemology, student performance

INTRODUCTION

In this era of information and communication technology (ICT), there has been an ever-increasing diversity in the sources and forms of course content. Course contents are available in various textual and multimedia formats. Instructors as well as students can gain instant access to and be able to freely transfer information. Thanks to the Internet! Therefore, teaching is no longer about presenting information to students that are otherwise not available to them. Teaching is about making the vast amount of available, diverse information learnable to students in a way that engages them in the process of learning.

Many learning theories and models exist in the literature. Numerous studies (e.g., Ortega-Tuleda et al., 2021; Zhang et al., 2020; Gonzalez-Gomez et al., 2016; Vanajakumari et al., 2015; Johnson, 2010; Olgun, 2009; Yuen & Hau, 2006) have utilized these theories and models to engage students at different levels – primary, elementary, and tertiary – in the teaching-learning process. Empiricist studies have deployed the transmission models in which knowledge is arbitrated, evaluated, and dispensed by the teachers, and students play the role of passive learners. Constructivists contend for the transaction and transformative models. In transaction models, knowledge is actively constructed by students in that they connect their past knowledge and experiences with new information (Santrok, 2004), and teachers assist them in their construction of new knowledge. Lastly, in transformative models, teaching creates conditions to transform learners on different levels such as cognitive, emotional, social, spiritual, creative, etc. (Johnson, 2010). The twenty-first-century teaching-learning process is witnessing a paradigm shift from the traditional empiricist philosophy of knowledge transmission towards a more innovative constructivist philosophy of knowledge transformation (Zhang et al., 2020). Thus, the methodologies of conventional lecturing are being replaced by more innovative pedagogical methodologies such as active learning approaches. These later approaches call for the creative use of the right teaching methods along with the right learning materials to better benefit the students (Mandula et al., 2012).

The extant literature shades light on the roles that various pedagogical methodologies play in the teaching-learning process and its outcomes. Evidence also suggests that, along with the creative use of the right teaching methods, the creative use of the learning materials is beneficial to students' learning abilities (Zhang et al., 2020). However, there is scant evidence in the literature as to how the learning materials shall be designed, organized, and presented to facilitate active learning by students. Though the active learning theories provide some evidence in the science disciplines, there is no evidence of the teaching-by-examples (TBE) in the business disciplines, especially, business statistics. The teaching-by-examples is an approach where learning objectives are achieved by creating lesson plans encompassing hands-on examples that take precedence in operationalizing the concepts and theories. This approach can be implemented regardless of the learning theories used and can employ a multiplicity of pedagogical methodologies, technologies, tools, techniques, and software. This study posits that students find the teaching-by-examples not only engaging and interesting but also effective in learning even complex ideas. Therefore, the objective of the study is to illustrate the TBE approach, test the hypothesis that the TBE approach results in better student performance than the traditional lecture method, and discuss the challenges of deploying the TBE approach. Appendix 1 illustrates the TBE approach.

PROPOSED RESEARCH HYPOTHESIS

This study posits that the TBE approach results in better student performance. The TBE approach plays a central role in the teaching-learning process in terms of successful student learning, student engagement, and disciplinary work. Successful student learning may embody mere knowledge acquirement in the traditional transmission models such as the traditional lectures and active knowledge construction in the transformation models such as the active learning theories and flipped-learning settings. The use of appropriate, relevant, and innovative examples helps operationalize the concepts and theories in settings ranging from passive knowledge acquirement to active knowledge construction (Zehr, 2004; Gonzalez-Gomez et al., 2016). As the TBE approach portrays, student engagement in learning – be it passive, sensory experience, or active learning – is substantiated if examples used in the teaching-learning process are relevant to the context and reflect the ontology of the subject matter domain. Thus, this study proposes the following hypothesis:

> *There is a significant difference between the mean performance of the students taught by the teaching-by-examples approach and of those taught by the traditional lecture method.*

RESEARCH METHODOLOGY

This study employed a single-factor two-level completely randomized design in teaching an introductory business statistics course for two semesters. The randomization process involved two stages: the random assignment of students to the control and treatment groups and the control and treatment groups to class timings. The experiment also embodied administering a common exam to both groups.

Random Assignments of Students to Groups

Fifty-seven students were enrolled in the course in one semester and sixty-six students in another semester. In each semester, students were randomly assigned to two groups – one representing the control group and the other the treatment group. In semester 1, the randomization resulted in 28 students in the control group and 29 students in the treatment group. In semester 2, the control group and the treatment group each had 33 students.

Random Assignments of Groups to Class Timings

During the time of enrolment, students were informed that their classes would be held one of two times and that they should enroll only if they were available at both times. In semester 1, the timings were Monday-Wednesday 2:00 pm to 3:30 pm and Tuesday-Thursday 2:00 pm to 3:30 pm. The random assignment placed the control group in the Monday-Wednesday 2:00 pm to 3:30 pm slot and the treatment group in the Tuesday-Thursday 2:00 pm to 3:30pm slot. In semester 2, the timings were Tuesday 6:00 pm to 9:00 pm and Wednesday 6:00 pm to 9:00 pm. The randomization resulted in the placement of the control group on Wednesday and the treatment group on Tuesday.

Common Examinations

Three exams were conducted in each semester – one final exam (i.e., Final Exam) and two exams (i.e., Exam 1 and Exam 2) during the semester. Exams were conducted jointly for both groups – administered at the same time in the same location using the same exam questions. Each examination was comprised of 30 multiple-choice questions, which appeared in different orders in each of the four versions. During the exams, students were organized, and the versions were assigned to them as per the layout presented in Table 1.

TABLE 1
LAYOUT OF THE EXAM VERSIONS ASSIGNED TO STUDENTS

	Col. 1	Col. 2	Isle	Col. 3	Col. 4	Isle	Col. 5	Col. 6
Row 1	Ver. 1	Ver. 2		Ver. 3	Ver. 4		Ver. 1	Ver. 2
Row 2	Ver. 3	Ver. 4		Ver. 1	Ver. 2		Ver. 3	Ver. 4
….								

All exams were proctored by four invigilators and students were not allowed to leave the exams until the end of the exams.

DATA ANALYSES AND RESULTS

Test scores represented the experimental variable for all exams in both semesters. These scores were recorded for a possible point of 15 for Exam 1 and Exam 2, and a possible point of 30 for the Final Exam. Test scores were first tested for homogeneity of variance using Levene's test (Levene, 1960) and for normality using the Kolmogorov-Smirnov test (Kolmogorov, 1933; Smirnov, 1939). The results of Levene's test and Kolmogorov-Smirnov test are presented in Table 2 and Table 3, respectively. As Table 2 and Table 3 indicate the exam scores satisfied the assumptions of homogeneity of variance and normality at the 5% level of significance.

TABLE 2
LEVINE'S TEST FOR HOMOGENEITY OF VARIANCE FOR TEST SCORES

Semester 1			*Semester 2*		
Test Score	**F-Stat**	**p-value**	**Test Score**	**F-Stat**	**p-value**
Exam 1	0.888	0.35	Exam 1	0.105	0.747
Exam 2	0.074	0.787	Exam 2	2.867	0.095
Final Exam	0.575	0.451	Final Exam	0.053	0.818

TABLE 3
KOLMOGOROV-SMIRNOV TEST OF NORMALITY FOR TEST SCORES

		Semester 1			Semester 2		
Test Score	**Group_ID**	**Statistic**	**df**	**p-value**	**Statistic**	**df**	**p-value**
Exam 1	1	0.094	29	0.200	0.141	33	0.093
	2	0.125	28	0.200	0.12	33	0.200
Exam 2	1	0.135	29	0.189	0.142	33	0.089
	2	0.113	28	0.200	0.091	33	0.200
Final Exam	1	0.134	29	0.195	0.112	33	0.200
	2	0.137	28	0.193	0.124	33	0.200

Note: 1 = Treatment Group, 2 = Control Group

To test the hypothesis that there is a significant difference between the mean scores of the teaching-by-example approach and the traditional lecture method, an independent samples t-test was employed using SPSS. SPSS provides the significance for the two-tailed test and the significance of the one-tailed test is the displayed significance divided by two. The direction of the one-tailed test is indicated by the t-statistic. A positive t-statistic indicates a right-tailed test for the mean difference between the treatment group and the control group ("One-tail Test for T-test of Independent Samples," 2020). The t-test results are summarized in Table 4 and Table 5.

TABLE 4
SUMMARY OF GROUP STATISTICS FOR TEST SCORES

		Treatment Group			Control Group		
Semester	**Test Score**	**N**	**M**	**SD**	**N**	**M**	**SD**
1	Exam 1	29	12.853	1.562	28	11.991	1.788
	Exam 2	29	12.172	2.019	28	10.071	2.308
	Final Exam	29	21.966	3.041	28	17.821	3.367
2	Exam 1	33	12.561	1.932	33	11.076	2.158
	Exam 2	33	12.545	1.405	33	11.288	1.850
	Final Exam	33	21.53	3.925	33	19.667	3.705

Note: N = Sample size, M = Mean, SD = Standard deviation

TABLE 5
INDEPENDENT SAMPLES T-TEST FOR TESTING THE MEAN PERFORMANCE DIFFERENCE

					p-value		
Semester	**Test Score**	**Mean Diff.**	**t-Stat**	**df**	**Two-tail**	**One-tail**	**Cohen's *d***
1	Exam 1	0.862	1.941	55	0.057	0.029	0.514
	Exam 2	2.101	3.661	55	0.001	0.001	0.970
	Final Exam	4.145	4.88	55	0.000	0.000	1.293
2	Exam 1	1.485	2.945	64	0.004	0.002	0.725
	Exam 2	1.257	3.110	64	0.003	0.002	0.765
	Final Exam	1.863	1.983	64	0.052	0.026	0.488

The mean differences presented in Table 5 are the differences between the mean scores of the treatment group and those of the control group shown in Table 4. The t-statistics are all positive and significant. This suggests that the proposed hypothesis is statistically significant. That is, the mean performance of the students taught by the teaching-by-examples approach is better than the mean performance of the students taught by the traditional lecture method. In addition, the effect sizes of the treatment have been estimated using Cohen's d (Cohen, 1988) and are shown in Table 5. Cohen (1988) suggests that a Cohen's d of 0.2 indicates a small effect, 0.4 a moderate effect, and 0.8 or more a large effect. As shown in Table 5, Cohen's d values indicate a moderate to large effect of the teaching-by-examples approach on the mean performance of the students.

DISCUSSION OF BENEFITS AND CHALLENGES

This study presented an illustration of the teaching-by-examples approach to teaching an introductory statistics course and experimented to test the hypothesis that there is a significant difference between the mean performance of the students taught by the teaching-by-examples approach and of those taught by the traditional lecture method. The findings suggest that the proposed hypothesis is statistically significant, indicating that the teaching-by-examples approach results in better student performance than the traditional lecture method. As the illustration demonstrates, the use of appropriate and ontologically relevant examples can bring about greater student engagement – ranging from passive to active learning – in the teaching-learning process. Goal-oriented examples such as inquisitive-informative examples versus inquisitive-critical examples can be utilized in different pedagogical models and methodologies. The inquisitive-informative examples can be used for transaction models employing the interactive methodology where instructors can assist students to construct new knowledge based on their past knowledge and experience. The inquisitive-critical examples can be used for transformative models employing constructivist methodologies such as the active learning methodology or inverse instruction methodology. The use of ontologically relevant, empirical examples can help bridge the gap between rigor and relevance. The examples used in the teaching-by-examples approach – be they inquisitive-informative or inquisitive-critical – can take various forms such as plain text, graphs, audio, video, conversation, role plays, etc. The teaching-by-examples approach can be applied not only to statistics but also to other similar management science courses such as operations research. Last but not least, this approach can serve a philosophy and a methodology in one such that it sets clear learning objective(s), creates lesson plans that encompass relevant examples, provides examples first and employs a multiplicity of pedagogical technologies, tools, techniques and software toward operationalizing the concepts and theories.

However, with the various benefits of the teaching-by-examples approach come to some challenges. The teaching-by-examples approach calls for a thorough understanding of the ontology of the disciplinary work (e.g., statistics), developing appropriate and relevant examples about the ontology, and selecting an appropriate epistemology (e.g., pedagogical model and methodology) to better facilitate the ontology of the disciplinary work. Along with ontology and epistemology, the articulation of learning outcomes and lesson plans plays a central role in this approach and often requires a tremendous amount of time and resources. The teaching-by-example approach requires that the overall course objective be partitioned into clear, manageable learning outcomes. Thus, it poses the challenge of breaking the whole course into parts in terms of lesson plans and learning outcomes and then fitting them back in.

CONCLUSIONS, LIMITATIONS, AND FUTURE DIRECTION

This study has several pedagogical and practical implications. It can benefit the teachers, students as well as textbook publishers. For teachers, the benefits can accrue in three ways: (1) the teaching-by-examples illustration provides an insight as to how they can apply the approach to operationalize the course learning outcomes; (2) the findings suggest that teachers can utilize the approach to bring about better student performance; and (3) the compilation of the thorough, ontologically-relevant lesson plans coherent to the overall course objective can provide an avenue to manuscript textbooks, workbooks, or guide books for subject matters where the teaching-by-examples approach is viable. The implication for students comes from the fact that they can obtain enhanced academic performance if taught by the teaching-by-examples approach. The textbook publishers can promote the teaching-by-examples approach to encourage authors in producing a new line of textbooks that can enhance student performance.

While this study provides multiple benefits, it is not devoid of limitations. The findings suggest that the teaching-by-examples approach improves student performance based on the experiments carried out over two semesters. A longitudinal study can be undertaken to not only observe the overall student performance but also the various components of student performance such as attendance, participation, etc. Future studies can also apply the approach to other management science courses and in different colleges and universities to gain comparative insights into the benefits of the approach.

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APPENDIX 1 – AN ILLUSTRATION OF THE TBE APPROACH

In this study, we illustrate the teaching-by-examples approach with the following learning objective: *To define and classify statistics*.

In a traditional teaching, an instructor may meet the learning objective, irrespective of the tools (e.g., PowerPoint slides, overheads, or plain utterance) used, by presenting some form of the following: *"Statistics is concerned with the collection, presentation, analysis, and interpretation of numerical data. There are two types of statistics. Descriptive statistics summarizes the information revealed in a dataset, presents the information in a convenient form, or looks for pattern in a dataset. Inferential statistics utilizes sample data to generalize about a larger set of data."*

In the TBE approach, the instructor will meet the same objective by having students involved in the process of defining and classifying statistics. The instructor will present students with examples in the form of in-class exercises, in which the instructor will solicit information from students tailored towards the learning objective. The instructor may begin with the following: *"It is easier to define and classify statistics by looking at how statistics is used. The following examples present some uses/functions of statistics. So, let's examine them and take note of lessons learned from them."*

The instructor can then engage the students in the discussion of the following exercises by asking leading questions and soliciting answers such as the ones provided as sample answers. These are the examples that I used in my classes and, and over the years, students' answers were in line with the ones presented here.

Exercise 1 – A Survey

Students were presented with a short survey shown in Table A1 and asked some follow-up questions given in the first column of Table A2. Column 2 of Table A2 records the sample answers to these questions obtained from students.

TABLE A1
A SURVEY INSTRUMENT

1. What is your age? _____ *years old.*
2. About how much do you weigh? ___ *pounds.*
3. Have you tried to lose weight in the past 6 months? □ Yes □ No
4. In general, how would you rate your health? □ Excellent □ Very good □ Good □ Fair □ Poor

TABLE A2
FOLLOW-UP QUESTIONS AND ANSWERS

Questions	Sample Answers
What do you see in this survey and what are their purposes?	We see a survey questionnaire with four questions, which are used to collect data from the participants regarding their age, weight, attempt to lose weight and health condition.
If this survey questionnaire is responded by 40 of you, I will obtain 40 responses. So, for recording purposes, can you suggest a short, meaningful name for each question	1. Age 2. Weight 3. Try-Lose-Weight 4. Health-Condition

Questions	Sample Answers
What would be your responses to the above questions?	1. Age: 27 2. Weight: 150 3. Try-Lose-Weight: Yes 4. Health-Condition: Very good
What will I end up with if I record 40 responses from you?	A dataset

Students are then given a dataset named SURVEYDATA comprising of 40 responses. The SURVEYDATA dataset is provided in Table A3.

TABLE A3
SURVEYDATA

Age	Weight	Try-Lose-Weight	Health-Condition	Age	Weight	Try-Lose-Weight	Health-Condition
74	118	No	Excellent	22	100	No	Very good
61	185	Yes	Very good	50	156	Yes	Good
63	210	No	Good	25	160	No	Poor
74	160	Yes	Excellent	73	270	No	Excellent
43	170	No	Very good	78	115	No	Poor
78	150	Yes	Good	66	185	Yes	Fair
40	155	Yes	Very good	55	150	Yes	Very good
63	202	Yes	Good	40	168	Yes	Good
64	120	Yes	Fair	65	165	No	Very good
35	160	No	Very good	51	130	No	Very good
53	140	No	Very good	56	190	Yes	Good
63	178	No	Very good	63	180	Yes	Very good
81	133	No	Good	53	269	No	Fair
43	160	Yes	Fair	38	172	Yes	Excellent
32	130	No	Excellent	48	216	Yes	Good
25	137	Yes	Good	47	217	Yes	Good
79	163	Yes	Very good	48	206	No	Very good
67	125	No	Poor	73	150	Yes	Very good
65	180	Yes	Excellent	40	135	No	Very good
21	100	No	Very good	52	175	No	Good

Exercise 2 – Data Presentations

Table A4, Table A5 and Figure A1 below have been derived from the SURVEYDATA. Comment on how these presentations are different from the SURVEYDATA.

TABLE A4
DISTRIBUTION OF RESPONDENTS BY AGE

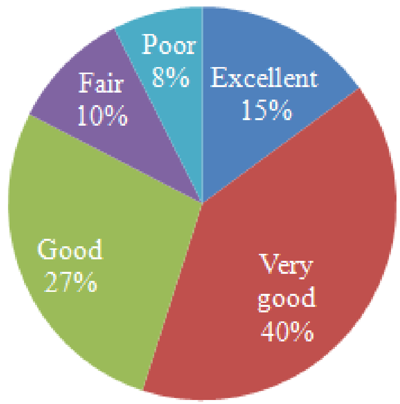
Age (in years)	Number of Respondents
20 – 39	10
40 – 59	12
60 – 79	17
80 and above	1
Total	**40**

TABLE A5
DISTRIBUTION OF RESPONDENTS BY TRY-LOSE-WEIGHT

Try-Lose-Weight	Number of Respondents	% of Respondents
Yes	21	52.5
No	19	47.5
Total	**40**	**100**

Note: The survey indicates that more than half of the respondents tried to lose weight.

FIGURE A1
A GRAPH OF HEALTH-CONDITION OF RESPONDENTS



Sample Answers

In Table A3, the respondents have been classified/divided into four age groups. The table helps us to see the distribution of the respondents in terms of their age. We are not able to see such distribution in the SURVEYDATA.

Table A4 shows the classification of the respondents in percentage regarding whether they tried to lose weight. The table indicates that more than half of the respondents (52.5%) tried to lose weight. The note to Table A4 is an interpretation of the summary results presented in the table.

In Figure A1, a pie chart depicts the distribution of the Health-Condition of the respondents. The graph shows, for example, that 40% of the respondents enjoyed very good health.

Exercise 3 – Interpretation of Poll Results

What do you observe in the use of the poll results presented in Table A6?

TABLE A6
FOLLOW-UP QUESTIONS AND ANSWERS

A proposal called 'cap and trade' would allow the federal government to limit the emissions from industrial facilities such as power plants and factories that some people believe cause global warming. Companies that exceed the limit could avoid fines of higher taxes by paying money to other companies that produced fewer emissions than allowed. Would you favor or oppose this proposal?

Results – Favor: 44% Oppose: 51% Unsure: 5%
(# of participants = 1,014; Margin of error ±3

Wolf Blitzer, The Situation Room, CNN, 5 May 2009 states:

"Our new CNN/Opinion Research Corporation poll shows just over half of the public opposes the so-called cap-and-trade plan to set a limit and a price on greenhouse gas emissions from large companies. That helps explain why negotiations on climate and energy legislation right now are so tense in the Congress."

Source: https://transcripts.cnn.com/show/sitroom/date/2009-05-05/segment/02

Sample Answers

We observe that the poll results were obtained from a small group of people (i.e., from 1,014 participants only). However, the results were generalized to the public (i.e., All Americans). That is, data obtained from a small group was used to draw conclusion about a bigger group.

Exercise 4 – Interpretation of Graphs and Summary Numbers

How do the numbers and the graph presented in Figure A2 regarding Google Inc. make sense to you?

FIGURE A2
GOOGLE STOCK PRICES

Google Finance, 16 June 2011

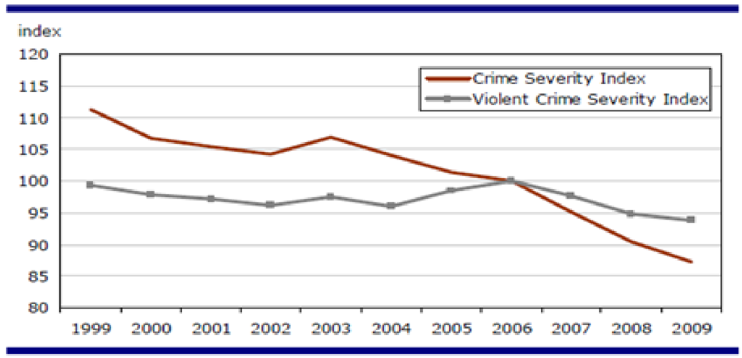
Sample Answers

The numbers show some summary information of Google Inc.'s stock performance. For example, we can see the range of Google Inc.'s stock prices for the day, the minimum and maximum stock prices for the past 52 weeks, the average number of shares traded in a day, etc. The graph shows the movement/trend of Google Inc.'s stock prices for three months.

Exercise 5 – Interpretation of Graphs

Figure A3 shows the crime severity and violent crime severity indexes in Canada from 1999 to 2009. What do observe in the graph?

FIGURE A3
POLICE-REPORTED CRIME SEVERITY INDEXES IN CANADA (1999-2009)



Sample Answers

The graph shows the trends in crime severity and violent crime severity as indicated by their respective indexes from 1999 to 2009. It also helps us compare the two indexes and their trends.

Putting It Altogether

What can you conclude from the lessons learned based on Exercise 1 through Exercise 5?

Sample Answers

The examples discuss (1) the collection and use of data; (2) the use of tables, graphs, and other numerical methods to present data; and (3) the analyses of data collected from a smaller group to draw conclusions about a larger group.

The instructor can then define and classify statistics by utilizing the findings of the students. A sample conclusion may look like the following: *"You have just defined and classified statistics. Statistics is, in fact, concerned with the collection, presentation, analysis, and interpretation of numerical data. As the examples point out, there are two types of statistics. The one that summarizes the information revealed in a dataset, presents the information in a convenient form, or looks for pattern in a dataset is known as the descriptive statistics. Exercises 2, 4 and 5 are examples of descriptive statistics. The other stream of statistics utilizes sample data from a smaller group to generalize about a larger group. The smaller group is called a sample, which is a subset of the larger group called the population. This stream is known as the inferential statistics. Exercise 3 is an example of inferential statistics."*