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VISA: Reducing Technological Impact on Student Learning in an Introductory Statistics Course

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1. INTRODUCTION

The present research is an attempt to assess easy-to-learn software tools in teaching of statistics in an undergraduate business program. The introductory business statistics course is a standard element of the curriculum in undergraduate business programs. For most students, this may be the only statistics course they will ever take. The content and topical coverage may vary from one institution to another, but usually the course starts with elementary descriptive concepts (such as mean, standard deviation, percentile, etc.), and evolves to the more complex inferential concepts. Because statistical theory is based on mathematical principles, the course traditionally presents a challenge to students and requires one or more prerequisite courses in relevant mathematical disciplines. At Christopher Newport University, for example, students cannot enroll in the business statistics course unless they have taken two courses offered in the mathematics department, an introductory statistic course and calculus for business applications. Students, therefore, come to the class prepared to learn the business applications of the material, most of which they have already seen in mathematical form.

Since a significant amount of statistical concepts are abstract in nature, teaching an undergraduate statistical business course is challenging. Another problem in teaching an undergraduate statistics course is the choice of software tools, if instructors choose to use software in the class. The complexity of most statistical procedures is such that "by-hand" computations are prohibitively long (take, for instance, computing the F-statistic for an ANOVA test). With that in mind, a lot of instructors have adopted software tools to perform statistical computations and tests. Different instructors may adopt different tools (such as Excel, SAS, SPSS, Minitab, etc.) based on personal or textbook preferences.

Our personal experience indicates that sometimes the software tool selected to teach a statistics course might present a limitation on the teaching quality. If the tool is comprehensive enough, and designed for professional use, a substantial part of the course can be spent just learning the menus and options of the software. In these cases, students' comments indicate that they view such use of class time as counterproductive. They feel that the time that they spend in class learning how to do the procedures in the software package could be better used learning statistical concepts and applications. The issue, therefore, is to minimize the learning curve for the software used in class as much as possible.

In teaching business statistics to undergraduate students we have used the Excel-based tool called VISA (Visual Interactive Statistical Analysis), Hodges (2008). The tool contains a collection of Excel-based templates to perform descriptive and inferential statistical procedures. The VISA user interface is common and consistent across different spreadsheets, which removes a substantial part of the learning curve. We will discuss the specifics of the VISA package later in this paper.

The purpose of the present research is multifold. First, we would like to argue that teaching business statistics to undergraduate students should concentrate more on

understanding the role of decision making using statistical results and its application to business problems rather than trying to communicate the intricate details of specific statistical tests. In our view, the objective of an introductory business statistics course is to educate students to be informed and intelligent users of a statistical toolbox that is focused on objective decision making. Second, we propose that the use of VISA can eliminate the need for the computer lab for instructional purposes, and we demonstrate that students can learn how to use VISA with minimal supervision.

The rest of the paper is organized in the following way: in section 2 we provide a literature overview, section 3 contains the methodology and experimental design. The VISA software tool used in this study is described in section 4, class grades and students evaluations of the course are discussed in sections 5 and 6 correspondingly. Section 7 concludes with results, practical implications, and future research ideas.

2. LITERATURE REVIEW

A number of researchers have addressed the use of software in undergraduate statistics courses. Alldredge and Brown (2006) conducted an experiment to compare the impact of instructional software on student performance. The authors investigated the use of two different types of multimedia packages on course performance. They hypothesize that different software packages used in a course result in different pedagogies and eventually influence student course performance. Moreover, Alldredge and Brown (2006) have investigated if the impact of different software packages would differ for females and males.

Garfield, Hogg, Schau, and Whittinghill (2002) performed a survey addressing the status of first courses in statistical thinking. Their findings reported major positive changes, especially in the use of technology and course revisions. They describe major efforts in courses by "there was a common theme among many instructors who stated that they focus more on concepts and big ideas and on data analysis and interpretation and less on computation, formulas, and theory" (p. 8). With respect to developing statistical reasoning, the authors "believe that appropriate content, a focus on data analysis and real problems, and careful use of high technological tools will help better achieve the suggested course goals and outcomes. However, no one as yet has demonstrated that a particular set of teaching techniques or materials will lead to the desired outcomes" (p. 10).

In this research we compare class performance in three sections of undergraduate business statistics course. Two of these sections were instructed in a computer lab using VISA software. The third section was scheduled in the regular classroom, and students passively observed instructor to perform data analysis using VISA software on the podium computer. Unlike Alldredge and Brown (2006), we have used the same software package in this research across all course sections. We hypothesized that if the software used for instruction is intuitive enough so that it does not require a major learning curve and can be mastered with minimal supervision, then the availability of the software for

instructional purposes in the classroom does not affect the student performance in the course. Such approach allows the instructor to spend less classroom time explaining details of the software package, and to place more emphasis on statistical concepts and ideas.

3. CLASSROOM SETTINGS

The findings reported in this paper are based on teaching *Statistical Thinking*, a business course taught in Spring 2006 at Christopher Newport University (CNU) by one of the authors. The *Statistical Thinking* course at CNU is an introductory statistical course required for pre-business undergraduate students. Normally, students take this course in their sophomore year after taking MATH 125 and MATH 135 (*Introductory Statistics* and *Calculus for Business*) taught in the Department of Mathematics. The textbook used for the business statistics course is Gerald Keller's *Statistics for Management and Economics*. The textbook contains a substantial number of examples of statistics applications to accounting, management, economics, marketing, and finance. Every chapter of the text contains practice problems, most of which have fairly large datasets that resemble "real-life" problems.

The topical coverage of the material adopted in the *Statistical Thinking* course is fairly comprehensive. The standard syllabus includes an introduction to the subject of statistics, basic statistical concepts, graphical and numerical descriptive techniques, concepts of discrete and continuous distributions, sampling distribution, one population inference (both confidence interval and hypotheses testing), comparison of two populations for independent samples and matched pairs, comparison of multiple populations using ANOVA, simple and multiple regressions, model building, and non-parametric statistics. Considering that the course meets three hours per week, and some of the time is devoted to exams, exams reviews, and homework reviews, students perceive this course as content-intensive.

It is our philosophy that business statistics at the undergraduate level should emphasize the application of statistical methods, rather than attempt to teach the internal workings of specific computations and formulae. Therefore, in teaching *Statistical Thinking* we completely abandon the "pencil and paper" methods. Students are informed at the beginning of the semester that for application purposes, various statistical methodologies and procedures can be viewed as a toolbox. For any business problem that has a dataset attached to it, finding the appropriate solution/decision for the question posed in the problem is a matter of performing several standard steps:
(i) translating a question posed in the problem from "business" terms into "statistical" language,
(ii) choosing the right statistical tool (procedure) from the toolbox,
(iii) applying the statistical tool chosen, and finally
(iv) interpreting the "statistical" answer in "business" terms.

The third step, applying the statistical tool chosen, is done using the software package. Since our objective in teaching this course is to concentrate on statistical concepts and applications, this step is viewed mostly as mechanical. Our goal is to deemphasize the

mechanical/computational component of the course and concentrate on the value-added steps of the business problem solution. With that in mind we wanted to use a software tool which (i) is easy to learn, (ii) has consistent user interface between different procedures, and (iii) is intuitive to use. To instruct students, we have used a statistical package called (Visual Interactive Statistical Analysis) VISA. VISA, is an Excel-based application, customized to perform certain statistical procedures and tests. We will discuss VISA organization and features in the next section.

In spring 2006 one of the authors taught three sections of the *Statistical Thinking* course. Two sections of the course were taught in a computer lab, so that students could follow and practice the statistical analysis of examples shown in the class on the computers. The two sections hosted 24 and 27 students, correspondingly. The third section was taught in a regular classroom, equipped only with a podium computer and an LCD projector. The students, therefore, did not have the capability to receive hands-on learning experience in the classroom, but rather could only passively observe the instructor performing analysis on the podium computer. This class hosted 26 students. The course-teaching environment was not established by design, but rather was due to the limited availability of computer labs for scheduling purposes. Students did not receive any prior information regarding the need for the computer equipment, so registration for different sections of the course resulted in three independent samples of students. Examples used for instructions were identical in all three sections of the course.

Testing of students' understanding of material in the *Statistical Thinking* class was performed using a combination of homework problems, quizzes, and tests. The course material was roughly broken down into four modules. About half-way into each module a quiz was given. Closer to the end of the each module, a homework was assigned. Each assignment required solving several problems. Each problem had a description of the business setting and an attached dataset to model a "real-life" scenario. With each problem students were required to answer a set of questions leading to a problem solution. Students were given a week to complete the homework. Completion of the homework required students to perform statistical computations using VISA templates. Upon submission of the homework, they were graded, returned back to students, and discussed in detail in class. When each module of the course was completed, and a corresponding quiz and homework were collected and graded, an exam was given. To ensure comprehensive coverage of the material discussed in class the exam contained multi-part problems offered from different topics or chapters covered in the lectures. Most of the problems offered on the tests assumed analysis of the business scenario, which had a downloadable data file attached to it. Students, therefore, were to use VISA Excel templates on exams to perform the analysis, and tests had to take place in the computer lab. The section of *Statistical Thinking* which was scheduled in the regular classroom with no computers was scheduled in a computer lab during the exam days. Three of the exams contained the material relevant to the corresponding sections or chapters of the course. The fourth and final exam was cumulative and included the material of the last part of the course as well as the inferential analysis topics from other three exams. The following weights were used to assess students' progress in the course:

quizzes – 15%, homework – 10%, first three exams – 15% each, final exam – 20%. Class participation and attendance accounted for the remaining 10% of the grade.

4. VISA OVERVIEW

In this section we describe the structure and organization of the VISA software package used in the BUSN 231 course.

Yilmaz (1996) proposed that relevant objectives of a statistics course aimed at non-statisticians should include (1) ability to link statistics and real-world situations, (2) knowledge of basic statistical concepts, and (3) ability to synthesize the components of a statistical study and communicate results in a clear manner. The author proposed to "revamp the traditional course design together with the creation of a new software tool that is currently unavailable." He states that although the use of software is common today in teaching statistics, typical software is meant for computations and not for teaching. Among software characteristics, the author mentions ease-of-use, and consistent graphical interface. Capabilities of such software should be similar to the most popular statistical software packages (Minitab, SPSS, etc).

Chervany, Collier, Feinberg, Johnson, and Neter (1977) "define statistical reasoning to consist of (a) what a student is able to do with statistical content (e.g., recalling, recognizing, and discriminating among statistical concepts), and (b) the skill that the student demonstrates in using statistical concepts in specific problem-solving steps." (p. 18). They further propose that the process of statistical reasoning consists of three stages: I – Comprehension; II – Planning and Execution; and III – Evaluation and Interpretation.

The VISA software discussed in this paper incorporates many of Yilmaz's (1996) suggestions. It is based on stages defined by Chervany, Collier, Feinberg, Johnson, and Neter (1977) stages, and includes visual interactive statistical analysis of data to facilitate the learning experience. It uses keywords to help students with scenario recognition, and guide them to the appropriate analysis procedure. Once keywords have been identified, they use menu-driven interactive Excel worksheets to view the data, complete the statistical analysis and interpret the results. The steps in the VISA model are discussed below:

Comprehension: Identify keywords and phrases. VISA characterizes the keyword process by the following:

- Identify the <u>data type</u> – Qualitative (Nominal/Ordinal) or Quantitative (Interval/Ratio)
- Identify the <u>number of variables</u> (populations) being investigated
- Identify the <u>type of analysis</u> that is required: descriptive, comparison, or relationship and whether it is parametric or non-parametric

- Identify whether the data is <u>dependent or independent</u>
- Identify <u>how the data is organized</u> for analysis (e.g. is it stacked or in columns)

Planning and Execution: The results of the classifications made in the comprehension stage are used to select the appropriate VISA analysis menu option. For example, if the student has identified the <u>keywords</u> in an analysis as --- quantitative data; 2 populations; parametric comparison; independent observations; in 2 columns --- they merely select the VISA menu item for *Quantitative by Column, 2 Columns Independent*. VISA organizes the comparison tests and all the pre-requisite "required condition procedures" and graphical data analysis in one place. Students do not have to traverse a textbook or use independent computer procedures to complete the analysis. They merely interact with the sequentially presented worksheets. VISA allows students to visualize data and concentrate on analysis rather than waste time on elementary manual calculations. We will discuss a specific example later in order to illustrate a typical analysis path while using VISA.

Evaluation and Interpretation: VISA presents results in terms that can be easily translated into the context of the problem being investigated. Color-coded and clearly labeled calculations are easily identified. VISA provides key numerical statistics such as the p-value and students are continually reminded by comments, such as: "p-value $< \alpha$, implies that the Null hypothesis is rejected". In addition, VISA also provides verbally descriptive phrases which help the student make the transition from computer output to "layman's presentation".

VISA is an Excel-based educational software package built on a big picture view of statistical analysis. This allows VISA to develop a set of integrated worksheets presenting a straightforward and seamless flow for performing statistical analyses. There is no multiple data entry or highlighting data multiple times for different independent analytical procedures, and pre- and post-hoc analyses are included in the same workbook. Once the data is entered, all other calculations (with the exception of a few background macros) are made automatically. This eliminates the independent nature of statistical analysis packages (including Excel and Minitab), which are introduced in the majority of contemporary introductory textbooks. Data can be entered in VISA in either stacked or unstacked format. The analysis of stacked data can be performed in either stacked or unstacked format. If the user desires to unstack the data before analysis, the "Unstack Data" VISA option should be utilized first.

When designing work methods, industrial engineers consider several factors: environmental working conditions, unnecessary motions, combining activities, the arrangement of the workplace, tools and equipment. The VISA concept presented herein addresses many of these factors. A somewhat sequential course delivery combined with the VISA toolkit organizes statistical procedures and their pre-requisite conditions all in one place. VISA provides memory pegs and eliminates the requirements for memorizing

complicated formulae and definitions.   It requires very little computer knowledge with the exception of a few basic Excel commands (such as the ability to copy and paste ranges of data). It also eliminates the need for multiple independent computer analyses with different hard to read outputs. The visual, interactive design of VISA allows the student to become more actively involved in the process of analysis. It also reinforces the appropriate procedural steps without having to flip back and forth through pages in a textbook. In addition, VISA provides both numerical and verbal output. The verbal presentation assists with student's ultimate interpretation in "layman" terminology. In short, the VISA concept bridges the gap between calculations and interpretation.

Figure 1 shows the overall VISA organization. When the CD is inserted, an Excel VISA Data Base (Data.xls) is launched. Students manually enter data by copying and pasting or import saved VISA data files into the Data.xls workbook, which serves as the driver for all VISA procedures and utilities. When a procedure for analysis is selected, another workbook is opened which accesses the data and column information in the VISA Data Base.   To provide students with directions how to use the application, PowerPoint demonstrations, printable .pdf instructions can be accessed from any point during the analysis. File options (Import Saved VISA File, Save VISA File, and Exit VISA), and data options (Clear Data, Multi-level Sort, and Un-stack Data) are provided.   Each procedure has a .pdf help document, which shows a detailed example of how it works, and each worksheet has instructions and callout comments.
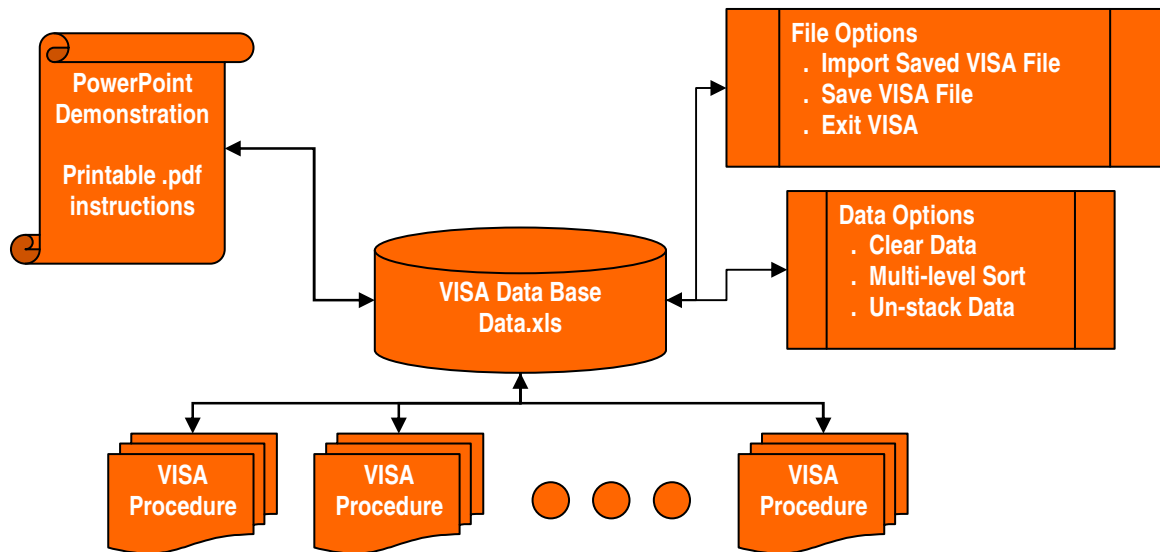

Figure 1: VISA Organization.

VISA provides statistical analysis for both stacked and un-stacked data for the following:

- Exploratory data analysis for both qualitative and quantitative data – graphical and numerical
- 1 population qualitative data – graphical displays of proportions by classification, z-confidence interval and hypothesis test for the population proportion

- 2 population qualitative data – graphical displays of populations proportions by classification, z-confidence interval and hypothesis test for the difference in two populations' proportions
- Chi-square analysis – observed classification proportions compared to hypothesized classification proportions
- Chi-square cross tabular contingency tables – tabular and interactive graphical display of cross tabular relationship with Chi-square hypothesis test results
- 1 population quantitative data – dot plot, box & whisker plot, histogram, verification of normality assumption, t-confidence interval and hypothesis test for the mean, and Chi-square confidence interval and hypothesis test for the variance
- 2 population independent quantitative data – dot plots, box & whisker plots, histograms, verification of normality assumptions, t-confidence interval and hypothesis test for difference of means, and F-test for equality of variance
- 2 population dependent quantitative data – verification of matched difference normality, t-confidence interval and hypothesis test for the mean of matched data differences
- 1 Factor ANOVA – dot plots, box & whisker plots, treatment scatter diagram, Bartlett's test for equality of variances, ANOVA table, pooled variance graphs of treatments on the same graph, and Fisher's LSD analysis
- Blocked 2 Factor ANOVA – treatment scatter diagram, ANOVA table, and pooled variance graphs for both factor treatments
- Complete 2 Factor ANOVA – ANOVA table, pooled variance graphs for both factor treatments, and graphical display of treatment interaction relationship
- Simple Linear Regression – summary regression output, ANOVA table, coefficients table, regression equation, significance tests, post-hoc residual analysis, Durbin-Watson test for autocorrelation, and graphical display of the original data with the regression equation with prediction and confidence interval bands
- Multiple Regression – graphical display of all XY relationships with significance test results, Pearson's coefficient of correlation table for all XY relationships, best one variable model, highly correlated X variables, interactive selection of variables to include in regression model with immediate feedback for summary regression output, ANOVA table, coefficient table, regression equation, significance tests, post-hoc residual analysis, Durbin-Watson test for autocorrelation, and graphical display of each XY plane showing original and regression data points
- Pearson's Coefficient of Correlation – correlation table, significance test results, and graphical scatter plots of the XY relationships
- Non-parametric procedures for both qualitative ordinal and quantitative data showing graphical displays of data with the corresponding hypothesis test results
  - Spearman Rank Correlation
  - Sign Test
  - Wilcoxon Signed Rank Sum Test
  - Wilcoxon Rank Sum Test
  - Kruskal-Wallis Test
  - Friedman Test

In addition, VISA also includes procedures for the following:

- Probability Distributions – discrete (Binomial and Poisson) and continuous (Exponential, Normal, Standard Normal, Student's t-distribution, F-distribution, and Chi-square) showing graphical representations and automatic table look-up values
- Statistical Process Control – range and mean charts for both known and unknown variation, proportion, and c-charts with above/below (A/B) and up/down (U/D) runs test
- Forecasting and Smoothing Methods – naïve, moving average, weighted moving average, exponential smoothing, linear trend, and seasonal relative models with forecast control charts

Since VISA was designed as an educational package for introductory statistical analysis, data set size is limited. The majority of VISA procedures handle up to two thousand data observations for up to sixty columns. Qualitative procedures handle up to twenty numerically coded classifications.

To illustrate the use of VISA lets analyze one of the problems offered to students on the final exam. The students are presented with the following problem description.

"An educational researcher would like to investigate the effect of social networking web sites (such as www.facebook.com) on students' performance in classes. He argues that students who are active users of www.facebook.com achieve lower grades in classes, because they pay too much attention to their social life, which eventually interferes with the study time. In order to test this statement, an experiment was conducted. A number of randomly selected students were asked to report if they are using extensively (over 5 hours a week) www.facebook.com or not, and also their GPA. The results for users and non-users were recorded in the file "Facebook.xls". Can we conclude that students who use www.facebook.com extensively, perform worse in their classes, than their peers who tend to use this web site much less frequently?"

Students are also presented with excel file that contains two columns of data: "Users", and "Non-Users" containing GPA figures (on the continuous scale 0-4) for students who use www.facebook.com extensively, and for the ones who are not active users, correspondingly. Students are expected to recognize that in this problem two columns of quantitative data are being compared. Since both samples are obtained as a result of a random split of a randomly selected group of students into users and non-users, then the data represent independent samples. Data should be copied into VISA Data Base, and both columns should be labeled "Quantitative" for further analysis.

Figure 2 shows an example of the VISA Data Base with the drop-down menu selection to analyze this scenario with: quantitative data, dependent observations, with data organized in 2 columns.
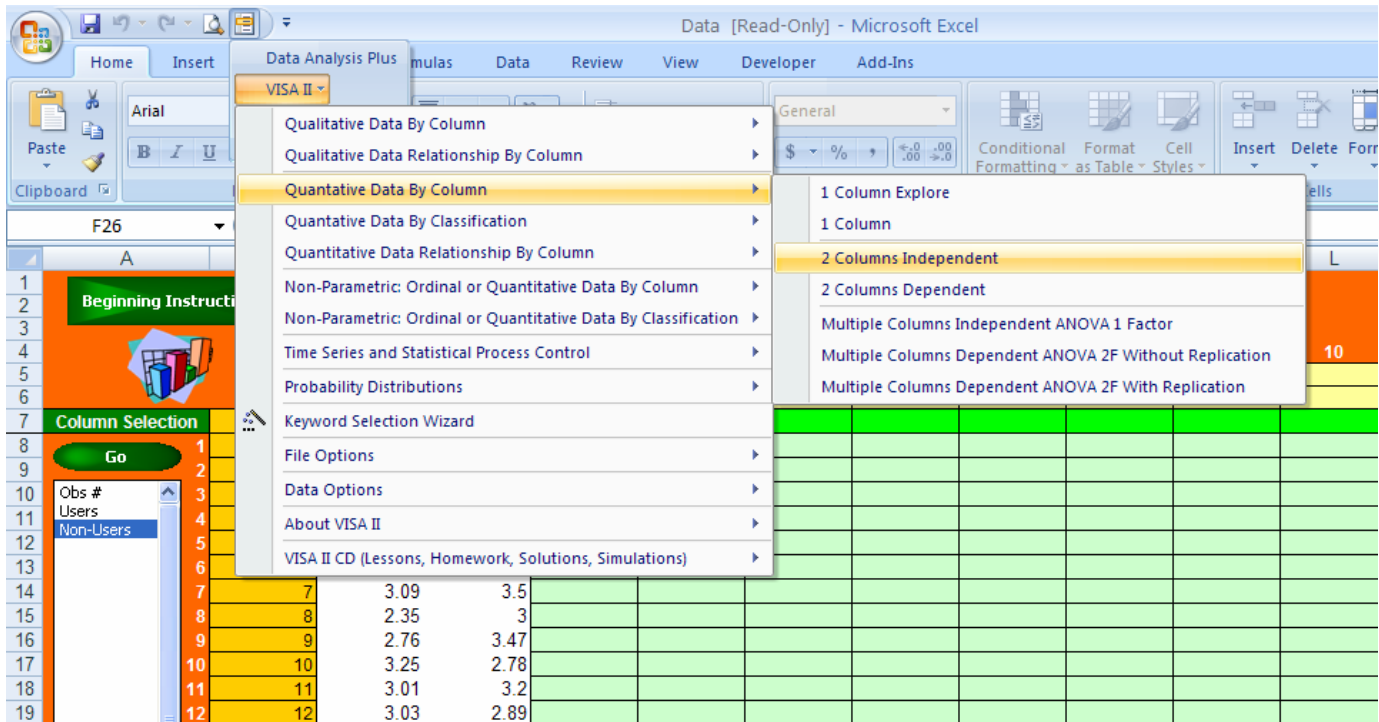
Figure 2: VISA Pull Down Parametric Analysis Option.

When the menu item shown above in Figure 2 (Quantitative Data by Column->2 Columns Independent) is selected, a workbook for the analysis is automatically opened and linked to the VISA data base. The menu options for the 2 population analysis are shown in Figure 3: select data to analyze (**SD**), graphical analyses (Dot Plot, Box and Whiskers, and Outliers – **DP,** and histogram - **HIST**) separately for both samples 1 and 2, numerical descriptive statistics (**NDS**), point estimates (**PE**) for both samples, comparison histograms of both populations on the same graph and scatterplots for both samples (**HISTB**), check for normality of two samples (**COMP1 and COMP2**), check for equality of variances (**CHKVAR**), confidence interval calculations (**CI**) for (μ_1- μ_2), and hypothesis test calculations (**HT**) for (μ_1- μ_2). Comments for each menu selection are displayed as a mouse-over tool-tip.
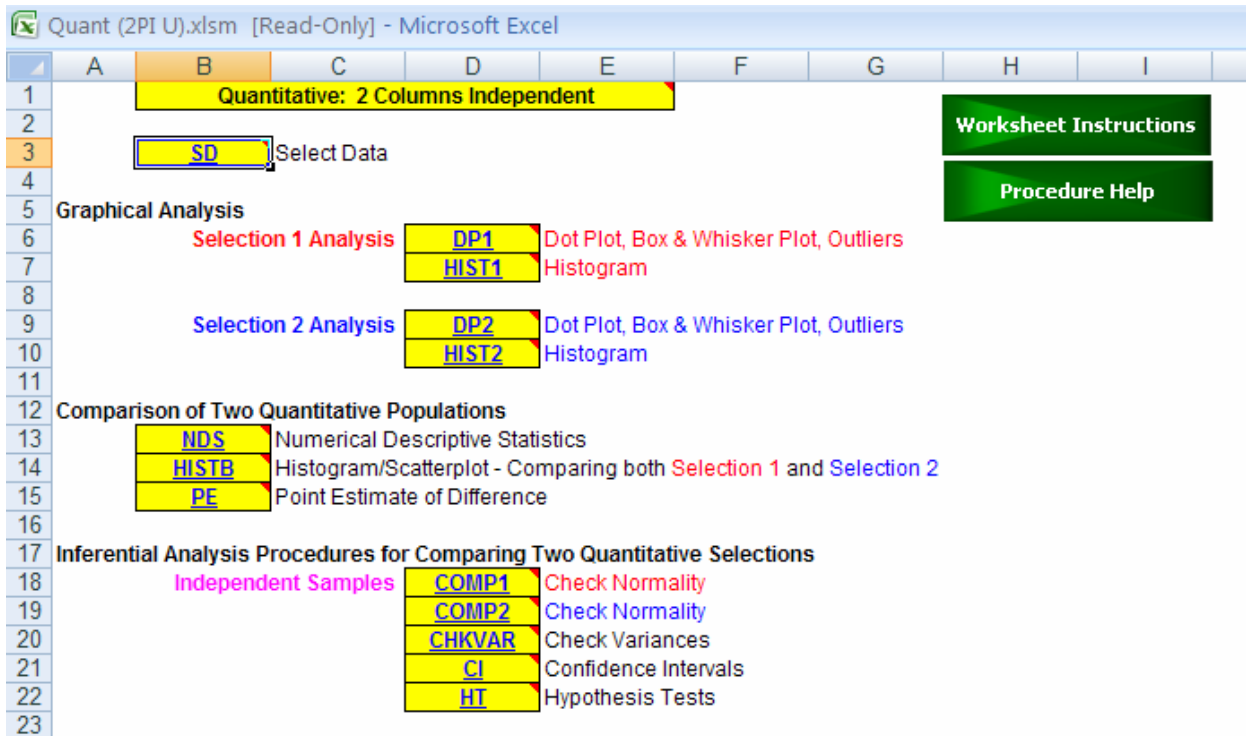
Figure 3: Two Columns Independent Quantitative Data Analysis Menu Options.

Figure 4, for example, shows the box & whisker plot, which identifies two outliers (in the graph and in the table at the left of the workbook) in sample "Non-Users". This also allows students to see that the observations are slightly skewed to the left and think about reasons why the two outliers may exist (two students with GPAs of 2.55, and 3.92, which represent unusually low and high observations as compared with the bulk of the sample). The statistical reasoning process is reinforced as students consider whether or not the outliers should be deleted from further analysis.
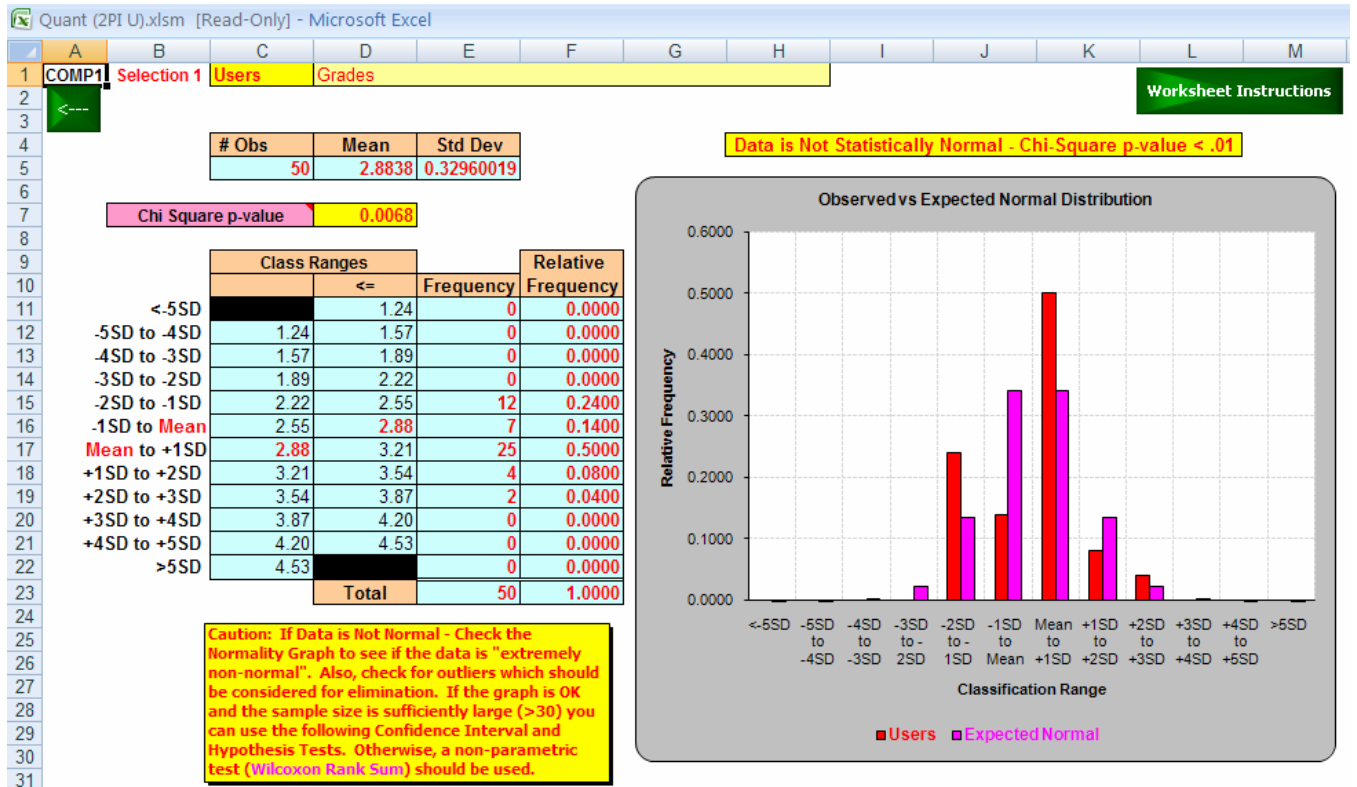
Figure 4: Box & Whisker Plot.

Students are supposed to understand that further analysis of the data depends on the normality properties of the two samples. Specifically, if both samples prove to be normally distributed, then we can proceed with a parametric analysis, and the same template can be used for parametric *t*-test of $(\mu_1 - \mu_2)$. On the other hand, if and one of the two samples fails the normality test, then the notion of the mean becomes unusable, and Wilcoxon Rank-Sum Test has to be employed from the non-parametric toolbox. Links to the corresponding normality tests (**COMP1** and **COMP2**) are conveniently located on the 2 Population analysis menu (see Figure 3).

Figure 5 shows a visual and Chi-square test for the comparison of "Users" data distribution (red bars) to the standard normal distribution (pink bars). Here we see that there is enough evidence (at $\alpha = .01$) to suggest that sample 1 does not come from a normally distributed population. Similar analysis is performed for the sample 2 when analyzing independent samples. In the event the Chi-square test indicates the data is not statistically normal, students are encouraged to evaluate visually whether the data is "extremely" non-normal. VISA uses the Chi-square test for normality rather than one of the many others because it is typically included in introductory statistics texts as a special case of Chi-Square Goodness-of-Fit test.

COMP1 Selection 1 Users Grades

Worksheet Instructions

Data is Not Statistically Normal - Chi-Square p-value < .01

	# Obs	Mean	Std Dev
	50	2.8838	0.32960019

Chi Square p-value	0.0068

	Class Ranges		Frequency	Relative Frequency
		<=		
<-5SD		1.24	0	0.0000
-5SD to -4SD	1.24	1.57	0	0.0000
-4SD to -3SD	1.57	1.89	0	0.0000
-3SD to -2SD	1.89	2.22	0	0.0000
-2SD to -1SD	2.22	2.55	12	0.2400
-1SD to Mean	2.55	2.88	7	0.1400
Mean to +1SD	2.88	3.21	25	0.5000
+1SD to +2SD	3.21	3.54	4	0.0800
+2SD to +3SD	3.54	3.87	2	0.0400
+3SD to +4SD	3.87	4.20	0	0.0000
+4SD to +5SD	4.20	4.53	0	0.0000
>5SD	4.53		0	0.0000
		Total	50	1.0000

Caution: If Data is Not Normal - Check the Normality Graph to see if the data is "extremely non-normal". Also, check for outliers which should be considered for elimination. If the graph is OK and the sample size is sufficiently large (>30) you can use the following Confidence Interval and Hypothesis Tests. Otherwise, a non-parametric test (Wilcoxon Rank Sum) should be used.

Observed vs Expected Normal Distribution

Relative Frequency (y-axis): 0.0000 to 0.6000

Classification Range (x-axis): <-5SD, -5SD to -4SD, -4SD to -3SD, -3SD to -2SD, -2SD to -1SD, -1SD to Mean, Mean to +1SD, +1SD to +2SD, +2SD to +3SD, +3SD to +4SD, +4SD to +5SD, >5SD

Legend: ■ Users ■ Expected Normal

Figure 5: Sample Data Distribution Comparison to Standard Normal Distribution.

At that point in the analysis students should realize that the sample "Users" is significantly non-normal, suggesting that a Wilcoxon Rank-Sum Test is appropriate to use with this data. Closing of the current template will bring up a VISA Data Base, and from there the drop-down menu item should be chosen to analyze this scenario with: Non-parametric analysis, Ordinal or Quantitative: 2 Columns Independent – Wilcoxon Rank Sum test, as is shown on Figure 6 below.
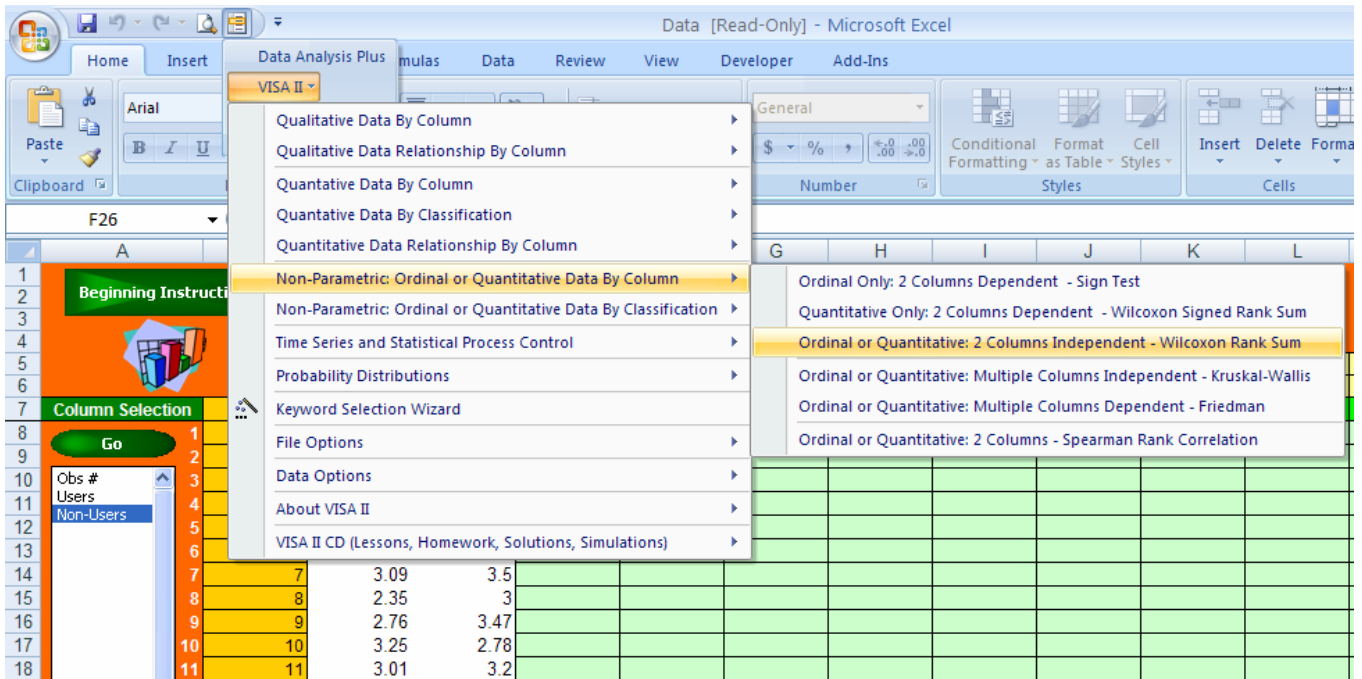
Figure 6: VISA Pull Down Non-Parametric Analysis Option.

When the menu item shown above in Figure 6 is selected, another workbook is opened and linked to the VISA Data Base. The menu options for Wilcoxon Rank Sum test are shown in Figure 7.
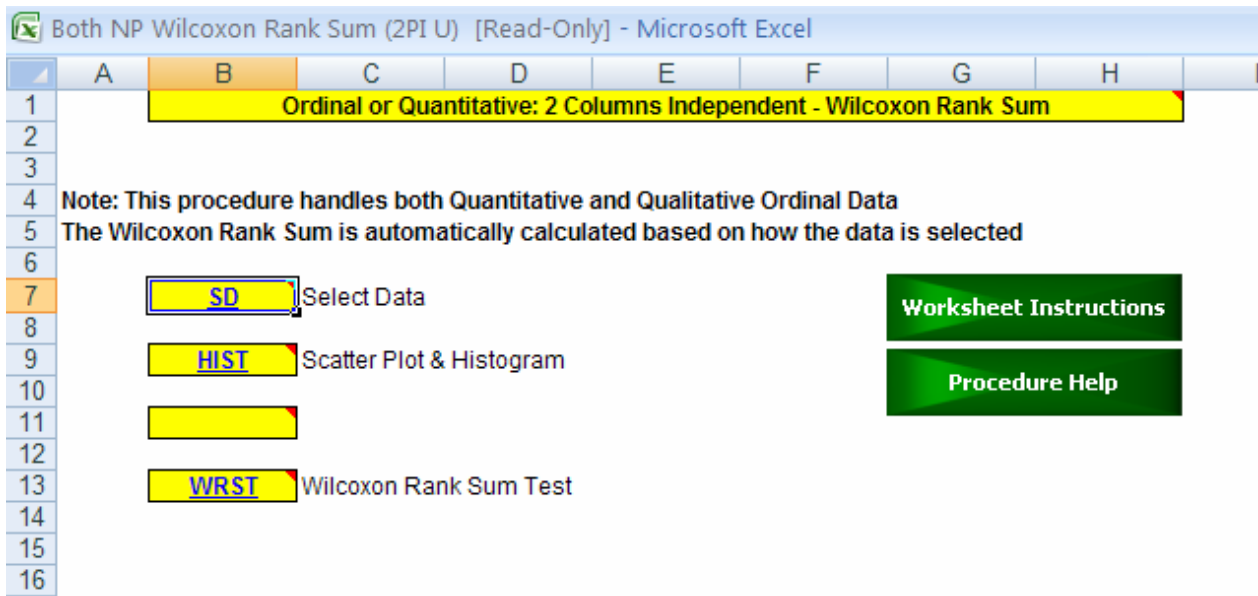

Figure 7: Wilcoxon Rank Sum Test Menu Options.

To answer the business question posed in the problem ("does excessive use of www.facebook.com negatively affect GPA?"), students have to formulate the appropriate statistical hypotheses and test them. Since we have identified that a non-parametric test should be used with the data provided, then the hypotheses should be formulated using

the notion of a "population location". Therefore, the alternative hypothesis to test in this problem has the following form:

H_1: the location of population "Users" is less than the location of population "Non-Users".

Figure 8 shows the hypothesis test screen. Students can select the form of alternative hypothesis from the list as "not equal", "less than", or "greater than". Also, the selection of significance level can be from the drop-down list. When selecting the form of the alternative hypothesis ("less than"), the hypothesis being tested is reaffirmed in the bright green cells in the middle of the worksheet, so that students can verify that they are testing a correct hypothesis. Test statistics and a corresponding p-value are automatically calculated. Spreadsheet contains a verbal description of what the p-value means with respect to whether samples provide enough statistical evidence to reject null hypothesis in favor of alternative. Eliminating the mechanical calculations encourages students to concentrate on the analysis. The final outcome expected from such analysis is a conclusion formulated in plain business terms similar to: "at 5% significance level, the evidence in samples is sufficient to conclude that www.facebook.com users receive statistically lower grades than non-users".

Figure 8: Wilcoxon Rank Sum Hypothesis Test Screen.

5. GRADES ANALYSIS

Student grades were used to compare performance in the three sections described above. We utilized the Kruskal-Wallis test to compare performance of the three different sections on quizzes, homework assignments, and exams. The final course scores were computed for each section based on a weighted average of quizzes, homework assignments and exams grades with weights discussed above in section 3. The final course scores serve as the basis for final course grade determination and indicate the overall cumulative performance of students throughout the semester. The hypotheses tested are:

H_0: Distributions of grades have same locations for all three sections of BUSN 231
H_1: At least two sections of BUSN 231 differ in the distribution of grades locations

The results of the tests performed for exams and final course scores are summarized in the Table 1. The Table includes also class scores averages (out of maximum 100 points) and standard deviations for all three sections being compared. Sections 1 and 2 were instructed in a computer lab with VISA software available at students' fingertips. Sections contained 24 and 27 students, correspondingly. Section 3 was instructed in a regular classroom. Twenty six students enrolled in this section were instructed in a regular classroom without computers. Students in this section observed passively how instructor performed data analysis using VISA on a podium computer.

	Exam 1	Exam 2	Exam 3	Final Exam	Course score
p-value	0.8822	0.2202	0.6942	0.8087	0.5303
Average					
Group 1	83.79	80.38	74.92	76.56	78.13
Group 2	81.89	83.11	72.81	77.15	80.46
Group 3	82.62	77.00	71.54	73.13	80.00
Standard deviation					
Group 1	13.68	11.64	16.89	9.48	8.65
Group 2	14.08	9.32	15.93	12.94	9.25
Group 3	14.81	12.91	20.35	19.25	9.97

Table 1: Statistical Analysis of Grades Distribution in three sections of BUSN 231

The Kruskal-Wallis test p-values indicate that the three sections demonstrate the same performance level in the course.

We combined the grades data from sections 1 and 2 which were both instructed in a computer lab in one data set. Doing so increased the size of the student cohort instructed in the computer lab. The grades in the combined group were compared using Wilcoxon rank sum test with the grades in section 3, which was instructed using VISA in a regular classroom without software at students' fingertips. The hypotheses tested are:

H_0: The grades distribution location for cohort instructed in a computer class (groups 1 and 2) is the same as the grades distribution location for section 3
H_1: The grades distributions location for a cohort instructed in a computer class is different from a grades distributions location for a section 3

The results of the test are summarized below in Table 2.

	Exam 1	Exam 2	Exam 3	Final Exam	Course score
p-value	0.9313	0.1196	0.5974	0.7425	0.4069
Average					
Sections 1 and 2	82.78	81.82	73.80	76.87	79.36
Section 3	82.62	77.00	71.54	73.13	80.00
Standard deviation					
Sections 1 and 2	13.79	10.46	16.26	11.34	8.96
Section 3	14.81	12.91	20.35	19.25	9.97

Table 2: Statistical Analysis of Grades Distribution in groups instructed with and without VISA software available in the classroom

Again, the results of the test indicate that distributions of the grades are the same for students instructed using VISA in a computer lab, and for students who were instructed using VISA without having software available in the classroom at their fingertips.

Based on findings, the absence of computers for students in the classroom was not a limiting factor on class performance. Students, who were not taught in a computer lab, were challenged to learn the workings of the software by themselves. Nevertheless, these students were expected to perform the analysis analogous to the other two sections, which were taught using computers in the classroom. Every exam given in the course normally contains 3 to 4 problems, each with multiple parts. A typical problem poses a business question and asks a student to perform relevant analysis, provide brief interpretation of results whenever appropriate, and formulate the conclusion of the analysis in plain, non-statistical terms. If the software used in the course is complicated to the extent that students cannot learn its capabilities by themselves, then it is reasonable to assume that a substantial part of a 50-minute exam would be spent looking for the right statistical tool, rather than concentrating on analysis of problems. This would result in worse performance for students taking a course in a regular classroom without computers. Our results indicate that performance was uniform across all three sections, regardless of availability of in-class computers and analysis software for instructions. This leads us to conclude that VISA is a statistical software tool, which is simple enough so that it does not impose limitations on student learning. Students are able to learn this tool on their own time with minimal supervision.

Second, we claim that if a software tool is intuitive to the point that it does not require a substantial learning curve then having classes in a computer lab does not promote better understanding of statistics. This claim is demonstrated by the fact that the student course performance across the three sections was statistically the same regardless of availability of software. As was previously discussed, our approach to teaching statistics is geared towards understanding what tools are available for data analysis in the "statistical toolbox" and ability of students to correctly recognize problem's statistical characteristics and pick the appropriate statistical tool. Selecting the correct statistical tool or procedure is based on answering a series of questions about the problem and characteristics of data for the problem. The questions are as follows:
    (i)   What data type(s) are used in the problem?

(ii)   How many populations are being analyzed?

(iii)   What is the objective of the problem: to describe a single population, to analyze a single population sample, to compare two populations, to compare more than two populations, or to analyze the relationship between variables?

(iv)   Is the distribution of the data normal? This question applies to interval data only, and it drives the selection between parametric and non-parametric tests to be used with the problem's data.

(v)   How were the data collected? This question applies to experimental design when comparing two or more populations. Students are supposed to understand the difference between various experimental designs and argue why they believe the specific design applies to the problem in hand.

After these questions are answered, the selection of the appropriate statistical test can be made. As one can see in the VISA description in the section above, the overall structure of the software interface is consistent with this approach, integrating seamlessly with the pedagogical approach instituted in the course.

6. STUDENTS EVALUATIONS AND COMMENTS

CNU uses the IDEA (Individual Development and Educational Assessment) student rating system to assess quality of teaching. IDEA evaluations analysis is administered Kansas State University (the IDEA Center). Students are asked to evaluate academic standards of the course, quality of teaching, and their progress in the class. The scores in different areas being evaluated are reported on a 5-point rating scale with 5 points being the highest. The overall index of teaching effectiveness (progress on relevant objectives) combines and summarizes ratings of progress on the course objectives identified by the instructor as important (weighted "1") or essential (weighted "2") (the IDEA Center). The IDEA Center regards this measurement as the single best estimate of teaching effectiveness. The IDEA evaluations of the three sections of BUSN 231 described in this study bear the teaching effectiveness indices of 3.9 and 4.2 for the two sections taught in the computer lab, and 4.1 for the section, which was instructed without computers in the classroom. These ratings indicate that students' perceived progress on the relevant course objectives was rated similarly in different sections regardless of software availability in the classroom. The IDEA evaluation forms completed by students also contain space where students can leave written comments. Comments left by students taught in the regular classroom indicate that they would have preferred having classes in a room equipped with the computers because this caused them to work harder in this class. But, as we have elaborated above, this circumstance did not represent limitations on the quality of teaching and students' progress in class.

7. RESULTS, CONCLUSIONS, AND PRACTICAL IMPLICATIONS

In this research we have demonstrated that VISA can be used as an effective teaching tool in an introductory statistics course. The software is intuitive, easy-to-learn, and user-friendly. Results indicate that students are capable of learning the software on their own time outside of the classroom with minimal supervision from the instructor. This, in turn,

allows more time for teaching important statistical concepts, rather than explaining details of different menus and software capabilities.

The practical implication of our findings is that VISA software can be easily incorporated into a class without a need for the computer lab. Garfield, Hogg, Schau, and Whittinghill (2002) state that about 25% of all instructors require students to learn a spreadsheet like Excel in a statistics course. VISA is based on Excel and does not require students to learn Excel built-in menus and functions. It allows seamless integration with the existing course syllabus without curricular changes, as it supports all standard tests and procedures normally covered in the undergraduate statistics course. VISA is well-documented and contains tutorials explaining how different tests and procedures should be used.

Garfield (2002) stresses the importance of developing statistical reasoning. The author states that "most instructors tend to teach concepts and procedures, provide students opportunities to work with data and software". However, "it appears that reasoning does not actually develop this way", and "students can often do well in a statistics course,…, yet still perform poorly on a measure of statistical reasoning such as the Statistical Reasoning Assessment". It is interesting, therefore, to investigate how students instructed with VISA software perform on the Statistical Reasoning Assessment.

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