CONSIDERATIONS FOR INTRODUCTORY STATISTICS COURSES: A MODEL FOR DEVELOPING STATISTICAL REASONING USING EXCEL® WORKSHEETS – VISUAL INTERACTIVE STATISTICAL ANALYSIS (VISA)

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ABSTRACT

Most students will only take one statistics course in their lives and the majority of them are not mathematically gifted. This paper discusses a unique pedagogical methodology for introductory statistics course delivery using the visual presentation of data as the basis for learning statistical concepts. Rather than turn students on to statistics, it has been designed to turn them on to the power of statistical reasoning and how it can be beneficial to their future careers. The methodology uses menu driven, integrated, visual, interactive, Excel® worksheets aimed at making the introductory course more understandable and pleasurable.

INTRODUCTION

The long-range contribution of statistics depends not so much upon getting a lot of highly trained statisticians into industry as it does in creating a statistically minded generation of physicists, chemists, engineers, and others who will in any way have a hand in developing and directing the production processes of tomorrow. - W.A.Shewhart & W.E.Deming

I don't remember my first statistics course, but I do remember teaching my first one. In 1976, as a mathematical sciences graduate teaching assistant, I used the 596 page Mendenhall, W. and Reinmuth, J.E., Statistics for Management and Economics, 2nd edition, Duxbury Press, 1974 [22].

The following year, Chervany, Collier, Feinberg, Johnson, and Neter [5] in their article addressing statistical reasoning and assessment wrote "Despite the enormous resources that have been devoted to the development of introductory statistics courses, from many viewpoints this course is far from an unqualified success. … In addition, teachers of this course often report that students are bored, find the course difficult, find it unexciting, and look forward to being done with it." [5, p. 18].

After retiring from a successful post graduate career in business, I was fortunate to be able to start teaching decision sciences and management courses at the College of Charleston, School of Business and Economics. My first attempt in the classroom was enlightening. With a few major exceptions, the statistics textbook essentially organized the same as Mendenhall and Reinmuth. It had more pages; more color; more real-world examples and integrated computer output from Excel® and Minitab®.

Much to my surprise, the experiences I had in my first statistics course at the College of Charleston in 1998 were the same as those in 1976. Even with better tools, the majority of the students were very happy when the course ended. In a particular lesson, they could calculate numerical statistics, input them into the appropriate formulae, calculate the correct statistical result, and get the answers in the solutions manual. But when it came to exams, many students found it difficult to recognize a specific problem scenario and became frustrated when their homework efforts did not produce good test scores.

I could not understand. Why was it not any better than my experiences 22 years earlier? The computer tools were significant improvements over the manual calculations and batch SAS routines I used in 1977, the textbooks included statistical stories, and there were real-world exercises which the student could use to sharpen their skills.

Many researchers including Smith [31], Garfield [9] [10] [11], Rumsey [30], Chance [2] [3], delMars [6], Wild and Pfannkuch [32], and Moore [24] [25] [26] are still addressing some of the same concerns Chervany, et.al, discussed in 1977. Contemporary reforms call for improvements in pedagogy, development of statistical reasoning skills, less probability, more active teaching, better use of technology and assessment.

Garfield, Hogg, Schau, and Whittinghill [12] reported the results of 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” [12, p. 8]. With respect to developing statistical reasoning and thinking, they go on to say, “We 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 yet demonstrated that a particular set of teaching techniques or materials will lead to the desired outcomes” [12, p. 10]. In addition to these issues, while the context of the recent article Bryce [1] focused on the broader subject of statistics education, and comments on the need for better textbooks at the introductory level. He comments, “All one would have to do is go to a university bookstore and examine the texts required for courses to see the calls for change have had very little impact on publishers and their authors … with few exceptions the message has not gotten through to those of our profession, mostly academics, who write our textbooks” [1, p. 3].

IMPEDIMENTS TO LEARNING STATISICS

Education is what remains when the facts one has learned have been forgotten. - B.F. Skinner

One of the key axioms I learned in my business career was “keep it simple.” Statistics educators expect a lot from entry level students. Personally, when I get several things to do, I have to spend a great deal of time organizing and prioritizing to facilitate a harmonious outcome. Many entry level students and many adults do not have these skills. There are several (not so simple) impediments or “misery” factors that statistics educators should recognize and address before we are ever successful. Some of the “miseries” which contribute to student learning are discussed in the following paragraphs.

First, let’s take a look at student anxiety. Hogg [17] says “students frequently view statistics as the worst course taken in college.” [17, p. 342]. Kettenring [19] says “the difficulties start early when students shy away from the study of statistics or put their feet in the water and are quickly turned off by what they see as statistical mumbo jumbo” [19, p. 1229]. Even the mathematically gifted enter a statistics course with trepidation. The non-mathematically inclined enter the course with hopes of passing. Students know the course reputation which is best described by complicated concepts and many hours of study. In a recent survey of one hundred fifty statistics students at the College of Charleston (CofC) and five hundred eighty seven students at Christopher Newport University (CNU) there were two surprising results: At CofC, forty-nine percent work more than fifteen hours per week and seventy-eight percent study less than a total of eleven hours per week; at CNU, fifty-six percent are employed in a full or part time job and eighty-eight percent study less than twelve hours per week. Eleven to twelve hours per week equates to approximately two hours for each of their five course load. Thus, student anxiety is exacerbated by the time requirement outside of class to practice statistical reasoning skills. Roiter and Petocz [28] believe "recognizing and addressing concerns about anxiety seems to be a vital initial step in the design of introductory statistics courses … the teaching method implemented should seek to promote – deep learning – which will reduce any anxiety that may exist with the student." [28, p. 3]. Smith [31] further states "The proper question is not: How can I make my lectures more brilliant? But rather, how can I help my students learn statistics?" [31, p. 1].

Many of my early pedagogical efforts were designed to make presentations more efficient Hodges and Hasbrouck [14] [15]. PowerPoint® presentations, templates to automate manual calculations and minimize the time required to learn Excel®, and easy to find data sets were incorporated in a web-based presentation. The results were better: Fewer drops and failures, and higher teaching evaluations. But, I was not producing statistically minded students. This became apparent when some of my statistics students also took my follow-up operations management course and could not recall concepts to which I knew they had been previously exposed.

We are not going to change student behavior. Other than being more mobile, it hasn't changed much since I was a student. I realized that if they weren't going to change that my success an educator was to consider a different approach to the delivery of the course.

Next, consider the textbook. Forester [7] indicates that students learn more easily by seeing the big picture first, and then by learning the details. However, most statistics textbooks are several hundred pages long and are written sequentially proceeding from one micro topic to the next. I haven't calculated the average page length, but over the last several years I have reviewed many and the shortest one was over 700 pages. None were written from a "big picture" point of view. For a 40 hour statistics course, this equates to over 17.5 pages per hour. These pages (even with the color and examples) do not read as easily a John Grisham novel. Students find it confusing and frustrating when some inferential procedures (e.g. differences of two means) require pre-requisite procedures to check required conditions which are scattered throughout the text. I compare this to looking at De Vinci's Mona Lisa randomly through a microscope, one brush stoke at a time and never taking a "step back" to look at the beauty of the painting. The majority of the textbooks leave it to the professor initiative to develop and present a macro view of statistics. In my experience, many of my colleagues don't do this. They merely start at page one and teach statistics in the sequence of their chosen text.

Many researchers' argue for the need to concentrate more on the bigger issue of developing statistical reasoning than developing a deep understanding of formal statistical techniques. Hahn and Horel [13] indicate "knowledge of statistical tools alone is not enough" [13, p. 198] and further indicate it is important to "sensitize students to the fact that, unlike problems in statistical textbooks, data are not generally delivered on the proverbial silver platter". [13, p. 199]. Hoerl [16] states "students' understanding and retention could be significantly enhanced by teaching the overall process of investigation before the tools". [16, p. 5]. Moore [25] states "We often ignore broad ideas in our rush to convey technical content. We spend too much time calculating and too little time discussing." [25, p. 1253]. Furthermore, Hogg [17] states "Good statistics is not equated with mathematical purity or rigor but is more closely associated with careful thinking." [17, p. 343]. Rumsey [30] further acknowledges "I feel that we should distribute statistical terms on a 'what you need to know, when you need to know it' basis, and make sure students 'need to know'. Just because a textbook author includes an idea in a book doesn't mean you have to teach it. Be selective." [30, p. 7].

Next, let's look at the mathematical formulae. Some of my non-decision science colleagues have difficulty reading, understanding and interpreting simple statistical formulae. With Ph.D.'s and several statistics courses on their transcripts, they are still frustrated by the mathematical presentation. An interesting anecdote: I was visiting a non-decision science colleague and noticed a multivariate statistics text in his book case. I remarked that I was surprised at his interest in the subject. He took the book from the shelf and showed me a slip of paper at page three and remarked that he had stopped there. He had stopped when he got to a formula he could not read. I looked at the formula and it was the formula to calculate the one population confidence interval for the mean. Imagine how the students with no experience feel and react.

Chance [2] says "I want my students to think of statistics as not just plugging in numbers into formulas, but a process for gaining information. Thus I feel it is important to evaluate student understanding of this process by requiring them to complete such a process from beginning (conception of the question of interest) to end (presentation of results)." [2, p. 2]. Rumsey [30] states "Just because a student can plug and chug and come up with a number doesn't mean the student knows what it is measuring or how to use it to solve a problem. … I have also used fewer formulas in my class and have found that I am more successful when I demonstrate the need for the statistic, lead students to discover ways to measure it, then talk them though the steps of finding it, all before a formula is used. I never motivate an idea with a formula." [30, p. 6]. However, she does defend formulas and calculations by saying "they do play a role in the student being statistically competent. However, they should not be the focal point or the end point of their knowledge." [30, p. 7]. I agree and feel the students should do a simple manual calculation of most formulae. After that, they should use "well organized" computer software on data sets large enough to visualize a representation of the situation they are analyzing.

Some textbook authors agree that time consuming manual calculations detract from focusing on the more important issues of scenario recognition, results and interpretation. For example, Keller and Warrack [18] state in the reasons they wrote their book were: "When we first began our careers in 1971, statistics was taught with an emphasis on manual calculations. It was believed that only by doing calculations by hand would students be able to understand the techniques and concepts. Calculations were quite time-consuming but required no more skills than the ability to add, subtract, multiply, divide and determine square roots. The textbooks published at the time reflected this pedagogy. Ironically a more important skill, the ability to identify the correct technique to use was neglected." [18, p. xvii]. Further they state, an important goal when they published their first edition was to teach students to … (1) identify the correct technique, (2) computer the statistics, and (3) interpret the results … for those courses that wish to use the computer extensively, manual calculations can be downplayed or omitted completely." [18, p. xvii].

Next, consider the statistical jargon: null hypothesis, alternative hypothesis, standard error, p-value, Type I error, Type II error, and so on. Student attention span is not very long and their memory is not very good. To them, definitions are something to be memorized or written on note cards for easy reference. Formulae and procedures have complicated steps. They are confusing, conceptually difficult to understand, and not easily recalled outside the classroom. This creates a major hurdle for the statistics educator. Students typically do a good job when instructed in a particular chapter/section. They memorize what they need to know and do all the homework. Most do well with one concept at a time. However, while they are able to recite the statistically correct definition (or have a note card with the textbook definition on it), they lack "deep" understanding. Without this understanding, when they have to recall a previously presented concept, they have to re-study and re-memorize.

Chance [3] discusses "… the dependency students develop on knowing which section of the book a question comes from. Students learn to apply procedures when directed, but then after the course are at a loss of where to begin when presented with a novel question." [3, p. 9]. Rumsey [30] believes statistics educators can be more effective by promoting understanding rather than memorizing definitions. She states "In my opinion, we shouldn't define terms using strong statistical and mathematical language – It doesn't help." [30, p. 7]. Garfield's research on assessing statistical reasoning [9] [10] [11] reveals "students can often do well in a statistics course, earning good grades on homework, exams and projects, yet still perform poorly on a measure of statistical reasoning." [11, p. 3].

Next, consider reading and interpretation skills. We want them to read a scenario and identify the problem to be solved. Furthermore, we want them to identify such things as the null hypothesis based on our renditions of "maintain the stats quo" or the "innocent guilty scenario". Many times these analogies are confusing and the student has difficulty making the relationship when the situation contains both relevant an irrelevant facts. In addition, we want them to identify the important statistical information in a complicated computer output, and recite a layman's explanation of the results. A little daunting, given that most textbook reinforcement conclusions are similar to "Reject or Fail to Reject Ho". I recently had one textbook author tell me that the reason the answers in the back were not explanatory was to minimize the number of pages in the book. The textbook was 900 pages long. Textbook authors have to do better; statistical terminology and number solutions are not good enough. Chance [3] confirms my point by saying, students "are accustomed to calculating one definitive correct answer that can be boxed and then compared to the numbers in the back of the text." [3, p. 13].

The textbook is all the students have when they can not get in touch with the professor. In my first business position (operations research manager), one of the most important skills I learned was to speak "business English". My mentor (Don McArthur, Ph.D.) stressed communications in terms that others in the presentation could understand. He felt analysis was 10% effort and 90% presentation. This basic business tenant is reaffirmed by Chance [3] who states "… reporting a mean or p-value should be deemed insufficient presentation of results. Rather the meaning is provided when these numbers are interpreted in context" [3, p. 7], and Rumsey [30] who says "The ability to interpret statistical information and draw a conclusion is critical in the workplace, and those who are good at it will be able to advance and be successful in their positions. Moreover, this is the truly fun part of statistics for students – seeing it used to answer questions in which they are most interested. Students don't have to love statistics for statistics sake; they can come to love statistics for what it can do – help them to understand their world." [30, p. 9].

Students do not know how to read mathematically. They try to read mathematics books like novels. I am not sure anyone really knows how to teach students to read or think mathematically, but I do believe we can help them identify key information to aid the process. I encourage students to use a pencil while reading and make side notes focusing on the following key things: type of data (nominal, ordinal, quantitative), number of populations (one, two or many), how the data were collected (independently, dependently) and finally to identify whether they are describing, making a comparison or identifying a relationship in the data.

Finally and hopefully, we ask the students to learn a computer package. I know some decision science professors who still believe the students learn statistics by calculating formulae manually. Thankfully, those of this mindset let the student use a calculator rather than pencil arithmetic. Calculations are time consuming and require only elementary or high school arithmetic skills and do not add pleasure or allow for development of statistical reasoning skills.

We also have to be careful that our students do not view the statistics course as a computer course. I was shocked when some of my early student evaluations indicated that my course was “a great Excel® course.” Even the most friendly statistical computer package is entirely un-user friendly to the inexperienced. They like textbooks are written for one standalone analysis at a time. Excel® does not even have post-hoc analysis procedures for simple procedures and requires a repetitively tremendous amount of time to develop simple graphical plots which should be the basis for all statistical analyses. Computer terminology is not the same in every package and does not match entirely with the text. This adds more confusion and creates more frustration for the untrained student (e.g. the Excel® ANOVA F-test p-value is called Significance-F). A simple conversion of a stacked data set can add to the “time misery” and take away from the time the student should spend learning and understanding a statistical concept.

These miseries create significant challenges for most students. None of the issues discussed above are insurmountable, but to make the statistics courses more effective, we need to be more conscious of the entry level student psyche. Given their immaturity, lack of organization skills and for many the “yet to be developed” quest for knowledge, statistics educators need to search for ways to minimize “student misery” and create a more pleasurable experience.

For most students the introductory statistics course is the only one they will ever take. For all students for whom this is a terminal course, the rigors and statistical analysis software probably should be different than those required of students who are going on to become mathematicians, engineers or scientists.

At the liberal arts, College of Charleston, an introductory statistics course (taught in the mathematics department) is required for all students. Most take this course during their freshman year. As a pre-requisite for other business courses, the School of Business and Economics requires a secondary introductory statistics course which focuses on business applications. Students taking the business course have vague memories and have retained very little from their mathematics statistics course.

Since business applications are the focus of my course, one of my major objectives is to try to teach business scenario recognition. If during their business career they encounter a situation which calls for statistical analysis; hopefully, they will recall a classroom presentation and recognize it. I know they won’t remember the statistical procedure or be able to refer to it by name. If they have to develop the required statistical analysis on their own, they will know that it is somewhere in a statistics textbook. I also want them to be aware that there are professionals who practice statistics for a living, and when very difficult analyses are required a professional should be consulted. I use the analogy: Carrot cake is my favorite desert. When I see two cakes, I want to be able to recognize which one is the carrot cake. I don’t remember the recipe for a carrot cake, but I know the recipe is somewhere in a cookbook. If I really want a carrot cake, I have two options: bake it myself or buy one from a professional baker. If I want one badly enough and the bakery is closed: I will go through all the “misery” to obtain the ingredients, find the cookbook, follow the procedure, and bake the cake. However, I realize if leave out one of the important ingredients, the cake will not turn out like I want. If, I really want a good carrot cake; I usually go to the baker and buy one.

This was another lesson during my business career. After graduate school, my job was to use quantitative methods to help business managers make better business decisions. As a fresh out of school, operations research manager, I learned that many business managers knew when statistics could be used to help them. They would call me or another person in the operations research department. We would work together to design the appropriate analysis. Later, as I advanced in my career and became a business manager, I realized that I did not have the time to be both a good business manager and a good statistician. In the real-world there is a need to have both. As Clint Eastwood said in one of his movies, “a man’s got to recognize his limitations.” Business managers don’t have time to both a good business manager and statistician at the same time. Someone once said that when a statistician becomes a manager they cease to be a statistician.

Perhaps our focus should be more like Deming and Shewhart proposed. In my introductory business statistics course, I do not take the approach that I am creating the next “best” statistician. Rather, I am developing a “statistically minded” appreciation for the power and beauty of using statistical analysis to unlock the story told by data and to use the information to make better decisions.

VISA may be a pedagogical toolkit that will help accomplish this goal.

VISA METHODOLOGY

Location, Location, Location – Realtor
Data, Data, Data – Statistician

Statistics is an art and science for extracting information from data. To this end, one must first understand the data before beginning any statistical procedure. And to fully understand data, it needs to be visualized.

Prior to discussing the **VISA** methodology and in addition to the many points cited in earlier references, a few more articles should be mentioned. Many of the concepts found in **VISA** and associated course delivery are an attempt to address the statistical reasoning process.

Wild and Pfannkuch [32] offer an excellent four dimensional framework for developing statistical thinking: 1 – Investigative Cycle; 2 – Types of Thinking; 3 – The Interrogative Cycle; and, 4 – Dispositions. However, I as Moore [26] believe the model is very complex and while thorough, it may be too daunting for the introductory student.

Chervany, Collier, Feinberg, Johnson, and Neter [5] “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 ins specific problem-solving steps.” [5, 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. In a follow up article Chervany, Benson, and Iyer [4] discuss an application of the process using a decision tree model to help students identify the appropriate statistical procedure for analyzing a specific problem scenario.

David Moore’s 1993 interview with Fredrick Mosteller [23] discussed, among other things, investigation of data and computing. Some of the excerpts follow:

"33 Moore: Have you changed your mind again or do you still believe that exploratory investigation of data is, for most students at the beginning, the proper way to approach statistics?
34 Mosteller: Yes, I do still believe that. I believe that students are very interested in findings from the data and are willing to work hard on it, and so, I think data-oriented statistical teaching is a good idea." [23, p. 5 – 6].
"53 Moore: … computing has not fulfilled its promise as a tool for teaching statistics rather than simply speeding calculations. How would you react to that? Also, what do you think are the appropriate uses of computing technology in teaching statistics at an elementary level?
54 Mosteller: … The big need is to help the students understand what is going on. I think, in a way that always been a difficult problem in statistics, for the student to figure out what the question is, formulate the question, and then manage to pick out a satisfactory method for answering the question. The complaint really was the same as of the students in the old mathematics courses: that they'd learned a lot of techniques and if anyone gave them a problem; they were ready --- except they didn't know which bag of tricks to pick up. Well, that same complaint still exists in a time when computers are available for solving the problem. What we may need is something I don't have, an interactive method to help the student find his way through the many different kinds of devices there are for solving problems and help pick out the appropriate one for the kind of question the student wants to answer. That may not be so hard once someone has decided this is the kind of help that they intend to give the student. I don't know of examples, but in principle there is no reason we shouldn't have it." [23, p. 9].

In a study which is consistent with comprehension stage of the Chervany, et.al., [4] [5] methodology: Quilici and Mayer [27] studied how introductory students categorize word problems and reported that students need to learn how to "ignore the cover story in word problems and instead focus on the experimental design and whether the variables are quantitative or categorical" [27, p. 158]. Gardner and Hudson [8] responded to the statement by saying "We would comment that it is not so much a matter of ignoring the cover story, since data always have to be understood within a realistic context; however, it is a matter of educating students not to be misled by irrelevant information in the cover story" [8, p. 3]. I believe both to be true.

Also, consistent with Chervany, et. al. [4] decision tree model, some authors even use decision tree flow charts to help students identify correct statistical techniques: Keller and Warrack [18] and Levine, Berenson, and Krehbiehl [21]. While these are very good, in my opinion they are too complex for the introductory student. A simpler model is necessary.

The **VISA** model discussed in this paper is based on Chervany, et. al. recommendations combined with data oriented visual interactive statistical analysis software to facilitate the learning experience. It uses keywords to help students with scenario recognition which guide them to the appropriate analysis procedure. Once, keywords have been identified, they use menu driven, visually 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 key words and phrases. **VISA** characterizes the keyword process by the following:

- Identify the data type – Qualitative (Nominal/Ordinal) or Quantitative (Interval/Ratio)
- Identify the number of variables (populations) being investigated

- Identify the type of analysis that is required: descriptive, comparison, or relationship and whether it is parametric or non-parametric
- Identify whether the data is dependent or independent
- Identify how the data is organized 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 keywords 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. The student does not have to traverse a textbook or use independent computer procedures to complete the analysis. They merely, interact with the sequentially presented **VISA** worksheet. **VISA** allows students to visualize data and concentrate on analysis rather than waste time on elementary manual calculations.

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 a CD Excel® based educational software package built on a big picture view of statistical analysis and has been developed without using Excel's built in procedures. This allows **VISA** to develop complete integrated worksheets presenting a straight forward 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.

Figure 0 show the **VISA** organization. When the CD is inserted, an Excel® **VISA Data Base** (**Data.xls**) is launched. Students manually enter 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** is selected, another workbook is opened which accesses the data and column information in the **Data Base**. In addition to a PowerPoint demonstration, printable .pdf instructions, 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.

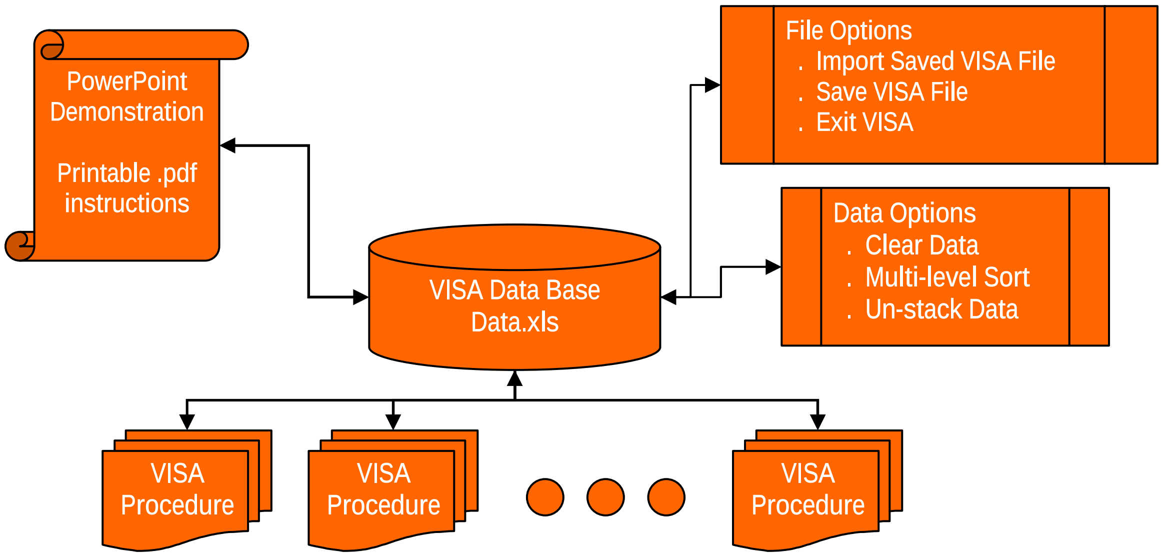

Figure 0: VISA Organization

DETAILED DISCUSSION OF AN EXAMPLE OF THE METHODOLGY OMMITTED FROM PROCEEDINGS

CONCLUSION

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. **VISA** is very easy to learn and requires very little computer knowledge with the exception of a few basic Excel® commands. 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 which creates a more pleasurable environment for learning.

With these improvements, "resistance to change" is still a major issue to be resolved, Bryce [1] pointed out the need for better textbooks. Introductory textbooks need to become more user-friendly for both the student and the instructor. Introductory textbooks need to focus more on the big picture and use keywords in examples to facilitate keyword recognition. The exercises presented in today's textbooks are good; but we need a friendlier flow, exercises with data sets (small and large) which foster "complete analysis requirements", and back of the book solutions explained in "real-world" language. In addition, we need to make it easier for instructors to change their method of teaching. Publishing requirements leave little time for the tenure tract faculty to devote to pedagogy. Improved textbook delivery and a simple easy to learn toolkit like **VISA** can help and will benefit both the student and the professor. As a step in this direction, I have developed a PowerPoint® lecture series with homework problems and detailed solutions (similar to the example shown above) as a cohort to the **VISA** software, and no longer use a textbook for my courses.

Charvany, et. al. define statistical reasoning as what a student is able to do with statistical content by three stages: "(I) Comprehension – the recognition of a problem or task as an instance of a more general category or prototype of methods for solving instances of the prototype; (II) Planning and Execution – the application of these methods to the specific instance at hand; and (III) Evaluation and Interpretation – the evaluation of the validity of the outcome from this application against the initial problem or question". **VISA** models these three stages and the results have been extremely positive from both the students and my perspective. Using keywords combined with the "all in one place" Excel® workbooks, students have a better understanding of the overall process of statistical analysis, and they feel this knowledge will help them make better decisions in their future careers. With respect to whether or not the **VISA** concept improves statistical reasoning, I can only offer a biased opinion based on my course objectives and there is probably a discrepancy in what I think they have learned (based on grades) and what they have actually learned. Hopefully, somewhere down the road in a career situation where statistics can be used, they will recognize it.

Rossman and Chance [29] provide a top ten list of recommendations for teaching the reasoning of statistical inference. [29, p. 298 – 304]. These are listed below:

1. *Insist on complete presentation and interpretation of results in the context of the data.*
2. *Help students to see the common elements of inference procedures.*
3. *Always examine visual displays of the data.*
4. *Always consider issues of data collection.*
5. *Stress the limited roll that inference plays in statistical analysis.*
6. *Help students recognize that insignificant results do not necessarily mean that no effect exists.*
7. *Accompany tests of significance with confidence intervals whenever possible.*
8. *Present tests of significance in terms of p-values rather than rejection regions.*
9. *Encourage students to use technology to explore properties of inference procedures.*
10. *Have students perform physical simulations to discover basic ideas of inference.*

With respect to whether the VISA methodology enhances statistical reasoning, I can only offer that it is consistent with the definition that Charvany et. al. propose. It is also compatible with the majority (#1, #2, #3, #5, #6, #7, #8, and #9) of the top ten list proposed by Rossman and Chance. With respect to simulations (#10), I use Java based simulations which are courtesy of Rice University, Rice Virtual Lab in Statistics with the permission of David. M. Lane [20] to present statistical concepts of histograms, means, medians, sampling distributions, and regression. With respect to the issues of data collection (#4), these are discussed in a presentation on how to collect a random, representative sample from a population of interest and are considered to be separate issues from the analysis process. In my courses, I use data sets which are associated with real world situations to which the students relate and we assume the data have been collected properly.

I do not proclaim that **VISA** and the course considerations discussed herein fully address the issues with teaching statistical reasoning; however, it may be a "directionally correct" approach for the introductory student. At least one observation that I have made is "it doesn't scare them off and an overwhelming number of students really enjoy the course".

Results with **VISA** have been very positive. I have used it in my courses for the last three years and Christopher Newport University, School of Business has adopted it to supplement their statistics textbooks.

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