

SOFTWARE TOOLS FOR INTRODUCTORY STATISTICS: A STUDENT-BASED COMPARISON

Mark Werner

The American University in Cairo, Egypt
mwerner@aucegypt.edu

We investigate experiences of first-year, non-science students with three data analysis tools during a pre-Calculus, introductory statistics course at the American University in Cairo, Egypt. Students could choose between DataDesk, Excel or StatCrunch, and were required to use one of these packages to analyze data collected for a semester project. It was especially important to evaluate these software packages from the point of view of a first-time user with no previous experience in either Statistics or advanced computer usage; several students were at first somewhat apprehensive of using a computer to analyze data. Among other outcomes, this investigation led to the development of student-based comparison of three software packages, from the perspective of a large group of potential users.

BACKGROUND

The benefits of including projects in introductory Statistics courses have been well documented. For example, Fillebrown (1994) states that a project facilitates statistical reasoning through open-ended questions, as well allowing students to work with real data and put into practice theory learned in the classroom. Chance (1997) notes that doing a semester project increases understanding of the statistical process, improves communication skills, and promotes student interest in Statistics. Smith (1998) modified the traditional course format to consist primarily of a series of projects undertaken throughout the semester under the theme 'Learning Statistics by Doing Statistics'. Smith found that student test scores improved 'dramatically', and that students were overwhelmingly positive towards the use of projects. Thorne and Root (2002) found that community-based research projects enable students to absorb material by constructing their own meaning for what they learn, by practicing and sharing classroom theory, and by increasing motivation through social relevance. McGillivray (2005) used own-choice projects and concluded that these were highly beneficial, by giving students a sense of ownership of their collected data, and by increasing relevance and motivation. Similarly, Kurji (2002) found a great deal of success implementing student-designed experiments as an important part of the introductory statistics course, with emphasis on understanding and interpreting the results of computer output, rather than on mechanical computations that have traditionally been the focus of this course. Thus, it seems that projects of varying designs, intents and lengths play an integral part of the learning process particularly among students specializing in non-scientific fields.

For the course in Statistical Reasoning at the American University in Cairo, a first-year, pre-calculus courses taken by non-science majors, it was decided to require a relatively short, multi-section project as part of students' overall assessment. This project consisted of two parts: Section A dealt with two categorical variables in which the aim was to determine independence through graphical examination of the conditional distributions, while Section B consisted of a simple linear regression and interpretation of results. Students had to collect their own data through a small but random survey, enter the data into a statistical computing package, make the graphs and most importantly, interpret this output. Goals for this project included gaining practical knowledge of surveys and the need for randomized selection, solidifying the concepts of conditional distributions and independence, enhancing understanding of correlation, regression and the role of residuals, developing computer literacy specifically in the realm of statistical analysis including graphical output, and enhancing writing skills including the presentation of information in a logical way. Of particular interest was the use of a computer to analyze data; quite a few students seemed rather apprehensive at the beginning of the semester about learning to use a new program. To help overcome this temporary obstacle, the instructor gave students a choice between three software tools: *StatCrunch*, *Excel* and *DataDesk*. *StatCrunch* was included in the list of choices because it won the *MERLOT Classics Awards* in 2005 (MERLOT is an acronym for Multimedia Educational Resource Learning and Online Teaching, more information

can be found at <http://www.merlot.org/Home.po>) as well as the 2005 *CAUSEweb Resource of the Year Award* (CAUSE is an acronym for Consortium for the Advancement of Undergraduate Statistical Education, more information can be found at <http://www.causeweb.org>). West *et al.*, (2004) describe *StatCrunch* in more detail. *Excel* was included because most students were already familiar with it (albeit not the data analysis aspects); it did, however, require the use of either the Data Analysis or EZAnalyze toolkits. DataDesk was a natural choice because it was pre-installed on a CD supplied with the prescribed textbook (together with ActivStats). Since *StatCrunch* is available free of charge on its website, and most students already had *Excel* on their computers or could use the campus labs, no additional purchase was necessary to use any of these packages, an important consideration for a developing country.

THE COMPARISON

A brief demo for each package was presented, and students were asked to select a program to analyze their data. They were allowed to switch to another package if they became unsatisfied with their original choice. 18 students chose to use *StatCrunch*, 12 chose *Excel* and only 1 student used DataDesk. Several students switched from DataDesk, because it did not seem as user-friendly and because it seemed that the other packages made nicer graphs. In fact the only student who used DataDesk would have preferred another package, but wanted to work at home and with a dial-up Internet connection, it would have taken some time to download the required toolkits for *Excel*, while *StatCrunch* required Java, which also required a long download time.

Reasons for Choosing a Software Package

Students were asked to select a reason for choosing their package from among (a) it seemed like the easiest package to use, (b) it seemed like it produced the nicest graphs, or (c) they were already familiar with it. Nearly all of the students who chose *Excel* did so because they were familiar with it, not because they thought it was the easiest package or that it made the nicest graphs. Although nobody had previously seen *StatCrunch*, approximately 60% of students chose it; 2/3 of *StatCrunch* users did so because it seemed like the easiest package to use, while the remaining 1/3 selected it because it seemed to produce the nicest graphs. The latter result was interesting because it showed there were several students who were willing to learn a new package mainly because of the attractiveness of the graphs, rather than its ease of use. This was not the majority, however, but nonetheless about 20% of the total class.

Comparison of User-friendliness

There were no significant differences regarding ease of use, with the students about equally divided between the two choices (a) Excellent, and (b) Good for both programs. There were, however, 2 students who rated *Excel* (c) Not Very Good, and 1 student who rated it (d) Terrible.

Comparison of Clarity of Statistical Results

Concerning the clarity of its statistical output, *Excel* users were equally split between (a) Excellent, and (b) Good, with 1 student rating it (c) Not Very Good. In comparison, *StatCrunch* users rated it (a) Excellent or (b) Good with a 2:1 ratio, respectively.

Comparison of Graphical Quality

Slightly more than half of *Excel* users rated its graphical output as (b) Good, while slightly less than half rated it (a) Excellent. There were, however, 2 students who rated it (c) Not Very Good. The situation was reversed with *StatCrunch*, with slightly more than half rating its graphical output (A) Excellent and slightly less than half rating it (B) Good.

Satisfaction with Chosen Package

Students were asked if they would be likely to use the same package again the next time they need to make graphs or conduct statistical analysis. 11 out of 12 students using *Excel* said they would use it again. The reason that somebody wanted to switch was that it took him a long time to make a scatterplot – apparently as much as the rest of the project. This was very

unfortunate since the instructor had informed the students to ask for help if they experienced difficulties with the software, but it shows how one small item can completely change the situation from favorable to unfavorable. Another student commented that she couldn't remember out how to plot the least squares line in *Excel* (which it calls the "trendline"), so repeated the regression analysis in *StatCrunch*, but didn't know how to plot the residuals, so finally returned to *Excel* and asked the instructor for help. Following the initial demo, approximately half the class asked the instructor for help on at least two separate occasions regarding how to draw a particular graph; regrettably those who did not ask, seemed to have spent an extra-ordinarily long time figuring things out. A valuable lesson to be learned here is the need for constantly emphasizing frequent communication with the instructor and to not spend much time searching for a particular graph. Regarding *StatCrunch* users, 17 out of the 18 users indicated they are likely to use it for future data analysis projects (with the dissatisfied student giving conflicting reasons). It is worth remembering, however, that the students were free to switch to another package at any time during their analysis, so it is natural to expect a very high degree of satisfaction. Comments ranged from, "*Excel* rocks!" to "I loved *StatCrunch* from the beginning, it was perfect." Another lesson seems to be that once students learn to use a software package, they are keen to use it again for future statistical analyses and don't feel a need to experiment with another package, or to find the "best" package. This underscores the importance of letting students learn a "good" package the first time, less they get stuck using an inferior program.

Effect of the Project on Statistical Comprehension

Students were asked if doing the project helped them understand the relevant statistical concepts; this was primarily intended to assess the overall success of the project rather than compare different packages. Indeed, the results for both *Excel* and *StatCrunch* were very similar. The majority of students indicated that doing this project "definitely" increased their understanding of the statistical concepts, while generally, the best students in the class – those who already understood the concepts – who replied that it only increased their understanding a little bit. The instructor took note that many questions were asked during the report-writing stage that involved interpretation of statistical output and which were directly related to classroom lecture material. Thus, even though certain topics were covered on the homework and midterm exams, final clarification seemed to have only been achieved when dealing with real data that directly involved the students. This reinforces what many of the aforementioned references found, namely that requiring students to analyze real data, together with allowing them to choose their own topic for investigation, provides a significant boost to increasing statistical understanding, motivation for studying statistics, and general enjoyment of the subject. A number of students commented on the interesting topics that they investigated and they had a lot of fun discovering previously unknown relations, and that they had gained self-confidence by being able to tackle an unknown question, obtain real data, and analyze the results to obtain a statistically valid answer.

RECOMMENDATIONS FOR FUTURE PROJECTS

Based upon student feedback, we offer several suggestions for Introductory Statistics courses:

- Similar to previous case studies, our experience indicates that projects involving real data and concerning a topic of interest to students can produce numerous benefits. These range from increased general enjoyment/motivation and statistical comprehension, to improved computer and verbal literacy.
- A statistical software tool to analyze student data is also highly recommended: to increase the quality of the graphical output, to save time for statistical computations which can then be focused on interpretation and understanding of results, and to increase computer literacy. The latter is important in order to encourage computer generated statistical analyses for future larger projects, when hand computations are not feasible.
- We strongly recommend providing students with a choice of statistical software packages. If students in this class had been forced to use *DataDesk* – the program which was distributed with the prescribed textbook, the result would not have been so positive. Allowing students

freedom for personal preference therefore leads to a better final outcome than forcing everybody to use the same package. Some students became extremely frustrated with *Excel* and loved working with *StatCrunch*, while others had a very positive experience with *Excel*. Providing a choice helps enables more of them to enjoy the computational aspects of the project.

- Although *DataDesk* is capable of serious statistical analysis, it seems a little short on user-friendliness, which does not make it ideal for first-year statistics students.
- Generally, those students that wanted to use a familiar package used *Excel*, while those who were willing to learn a new package that seemed easier to use and/or create nicer graphs, chose *StatCrunch*. In the end, nearly everybody was highly satisfied with their chosen package and indicated they would use the same package for future statistical projects and/or graphs.
- Although the differences were not statistically significant, *StatCrunch* nonetheless received higher ratings than *Excel* for (i) user-friendliness, (ii) clarity of statistical analysis and (iii) quality of graphical output.
- Several students mentioned that *StatCrunch* was slow to use because the analyses were performed online, and that they would not recommended it for dial-up Internet connections. This needs to be kept in mind for developing countries, and implies that *StatCrunch* should not be forced upon the whole class, since those without fast Internet connections would be at a disadvantage.
- It is essential that the students be able to contact (and receive timely feedback from) their instructor and/or assistant regarding specific aspects of their computer package. Sometimes students spend large amounts of time – unnecessarily – trying to figure out how to do a certain type of plot or feature, which could be explained within minutes.
- It is very helpful if the instructor can view the actual data files of the student to help them with specific problems. For *StatCrunch*, the student can log on to their account (online) in the instructor's office and go through the analysis together. After hours, students can “share” their data files with the instructor online and get specific advice. In *Excel* such assistance is also possible if the student sends the file to the instructor (e.g., by email).
- Whatever package the students learn to use first, they will probably continue to use for future assignments. Thus, this first package needs to be a “good” statistical package. Since some concern has been raised about *Excel* as a statistical analysis tool, this might indicate that it might not be entirely beneficial to let them use *Excel* for such projects as this would lead to continued use for future statistical analyses.

REFERENCES

- Chance, B. L. (1997). Experiences with authentic assessment techniques in an introductory statistics course. *Journal of Statistics Education*, 5(3).
- Fillebrown, S. (1994). Using projects in an elementary statistics course for non-science majors. *Journal of Statistics Education*, 2(2).
- Kurji, P. (2002). Statistics made alive. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching of Statistics*, Cape Town. Voorburg, The Netherlands: International Statistical Institute.
- McGillivray, H. (2005). Criteria, standards and assessment in statistical education. *Invited Paper Meeting 50: Quality Assurance in Statistics Education*, Paper presented at the 55th Session of the International Statistical Institute, Sydney, Australia.
- Smith, G. (1998). Learning statistics by doing statistics. *Journal of Statistics Education*, 6(3).
- Thorne, T. and Root, R. (2002). Community-based learning: Motivating encounters with real-world statistics. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching of Statistics*, Cape Town. Voorburg, The Netherlands: International Statistical Institute.
- West, R., Wu, Y. and Heydt, D. (2004). An introduction to *StatCrunch* 3.0, *Journal of Statistical Software*, 9(4).