TECHNOLOGY AND TEACHING

The Utility of Computer-Assisted Power Analysis Lab Instruction

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Undergraduate students (N = 47), enrolled in 2 separate psychology research methods classes, evaluated a power analysis lab demonstration and homework assignment. Students attended 1 of 2 lectures that included a basic introduction to power analysis and sample size analysis. One lecture included a demonstration of how to use a computer-based power analysis calculator, whereas the other lecture did not. Students then completed a homework assignment (with or without the power analysis calculator). Compared to students who did not use the power analysis calculator, students who did reported that the lab and homework assignment increased their understanding of power analysis and increased their overall level of interest in their research projects. These students also recommended using the lab in future courses.

Students conducting research, or enrolled in research design and methods courses, need to know how much data they need to collect for their projects to demonstrate a significant effect, if there is one. A power analysis is useful for this purpose, but power analysis calculations can be time-consuming when using complex designs. However, computer-based power analysis calculators that can simplify the task of determining an adequate sample size are readily available. My purpose was to determine whether a brief introduction to the basics of power analysis with the aid of a computer-based power analysis calculator, compared to basic power analysis instruction on its own, enhanced students' interest in their research projects and increased their intentions to conduct power analyses for future research projects.

In light of research that suggests that use of computer-assisted instruction (CAI) can enhance the learning experience (Traynor, 2003; Worthington, Welsh, Archer, Mindes, & Forsyth, 1996), I hypoth-

esized that basic instruction on power analysis would have a greater impact on student interest and understanding when paired with a power analysis calculator demonstration. My thinking was also consistent with suggestions to "modernize" the classroom with CAI and to prompt students to become more active with new technology (Erwin & Rieppi, 1999; Ralston & Beins, 1999).

Method

Participants

A total of 47 students from two psychology research methods classes attended one of two separate lectures on power analysis (either with a power analysis calculator demonstration or without it) and completed a brief homework assignment during the midpoint of an academic semester. I presented the power analysis lecture to each class 1 week prior to the homework assignment due date.

Power Analysis Calculator

GPOWER (Faul & Erdfelder, 1992) is a computer-based calculator that computes power analyses and sample-size analyses for a wide range of statistical tests. The output of a GPOWER power analysis provides users with feedback on their input as well as information that is useful for understanding the relationships among various concepts essential to power analysis (e.g., sample size, significance level, power, effect size).

GPOWER is an independent program that does not require the user to install any other statistical software.

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GPOWER.EXE                                              _ ⊡ ✕
 ≡  Tests  Colors                          178kB free    12:48:07
                                                       Analysis
      Calculate          Calc Effectsize          Graph      (•) A priori
                                                       ( ) Post hoc
  Effect size f    0.25      Lambda    9.9375            ( ) Compromise

  Alpha            0.05      Critical F(2,156)=3.0540     I prefer...
                                                       ( ) Speed
  Power            0.80      Total sample size 159       (•) Accuracy

  Groups            3             Actual power 0.8049    Hypothesis
                                                       (•) Global
                                                        ( ) Special

  Protocol
  ------ F-TEST ON MEANS IN THE ANOVA, A PRIORI ANALYSIS, ACCURACY MODE ----
  Effect size f=0.25, Alpha=0.05, Power=0.60, global
  Total sample size=105, Critical F(2,102)=3.0855, Lambda=6.5625
  ------ F-TEST ON MEANS IN THE ANOVA, A PRIORI ANALYSIS, ACCURACY MODE ----
  Effect size f=0.25, Alpha=0.05, Power=0.80, global
  Total sample size=159, Critical F(2,156)=3.0540, Lambda=9.9375

  Effect size conventions: small = 0.10  medium = 0.25  large = 0.40
  Alt X Exit | F-test on means in the ANOVA
```
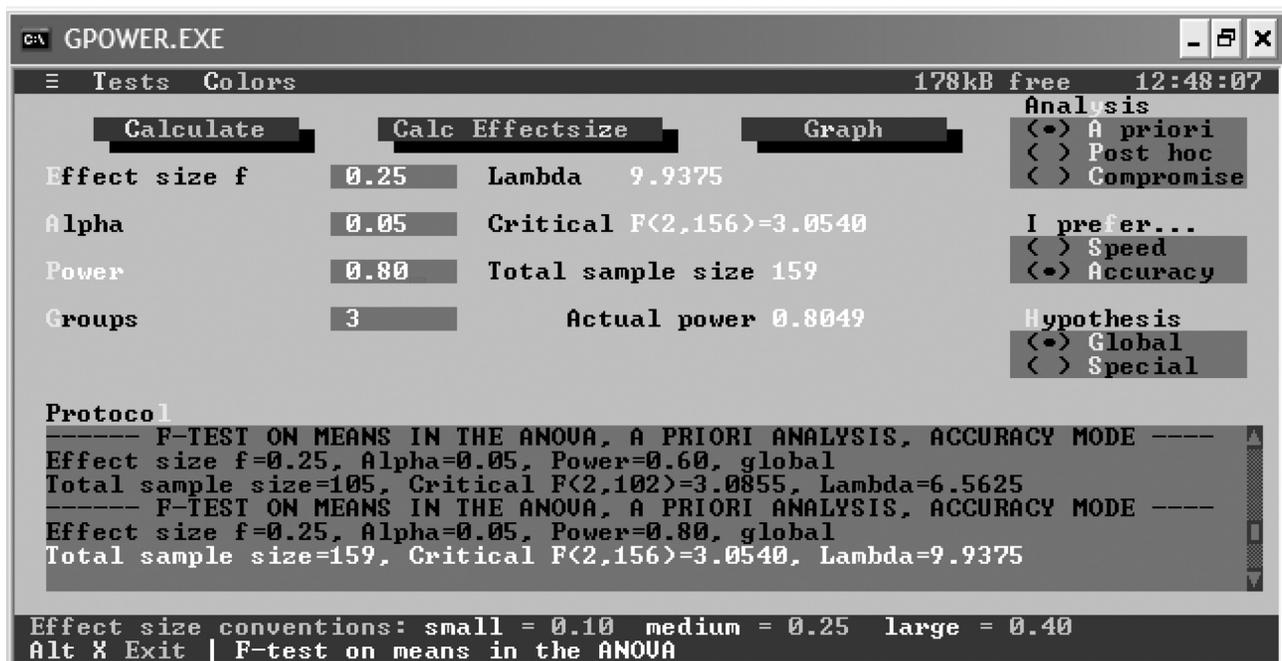
Figure 1.   GPOWER interface.

As a useful teaching tool, GPOWER graphs the relation between any two of the relevant power analysis components. For instance, the relation between effect size and power can be plotted for any statistical test. Students can learn the basic relation between the input components by changing the input and paying particular attention to how minimum sample size changes as a result of changes in effect size, alpha level, or power value and by graphing these components. GPOWER also displays the conventional small, medium, and large effect size values that correspond to the particular test employed (see Figure 1). Finally, GPOWER is free, and students can download it from the Internet (see http://www.psycho.uni-duesseldorf.de/aap/projects/gpower/index.html).   See Buchner, Erdfelder, and Faul (1997) and Erdfelder, Faul, and Buchner (1996) for additional information regarding technical details and potential uses of GPOWER. There are other power analysis calculators available on the Internet, such as SamplePower 2.0 (SPSS, Inc., 2001), UnifyPow (O'Brien, 1998) and nQuery (Statistical Solutions, 2000). SamplePower 2.0 is an SPSS product; it might be one of the most versatile power analysis calculators available, but with the extensive number of options available, it might confuse novice users. Thus, the program might not be user friendly enough to use in an undergraduate lab demonstration. In addition, SamplePower 2.0 requires a math coprocessor (e.g., SPSS), and the cost is $500. An alternative is UnifyPow, a SAS macro that can be used in conjunction with SAS commands. This power analysis calculator requires the user to own SAS, as well as have some familiarity with SAS programming language. UnifyPow's "counterpart," GraphPow, also graphs power analysis results, but it also requires familiarity with SAS programming language and is probably well beyond the scope of what a basic power analysis demonstration requires. Another power analysis calculator, nQuery, is perhaps just as user friendly as GPOWER. With an intuitive interface, it is easy to use and will compute power analyses for all of the designs that GPOWER does, and then some. nQuery also includes the graphing of power components. A downside to nQuery is the cost (over $700). Thus, GPOWER appeared to be the best option with regard to its analysis options, availability, cost, and potential user friendliness.

Procedure

Power analysis instruction. Conducting a power analysis involves some understanding of significance level, effect size, and power. Thus, before proceeding to the description of the assignment, I introduced students to the necessary components in both classes. I introduced students in both classes to basic power sample tables (see Cohen, 1988) and demonstrated how to use the tables to determine the number of participants they would need for seven different scenarios (e.g., "With a significance level of .05, three

groups to compare, a medium effect size of .25, and power of .60, how many participants would be needed to demonstrate a statistically significant effect?"). For each scenario, I first asked students to guess how many participants would be needed and then asked them to use the power sample tables to determine the correct answer.

I introduced students in the lecture with the power analysis calculator demonstration to GPOWER. During the GPOWER demonstration, I highlighted the operations of the calculator (including how to change the test, how to calculate effect size from a previous article using the GPOWER calculator, and how to set the components needed to calculate the power analysis). These students computed the final three of seven scenarios with the assistance of GPOWER.

Assignment implementation. I instructed students to complete a homework assignment worksheet by the following week. The worksheet consisted of five questions. The first three questions varied in the input components of the power analysis, similar to the in-class examples. Students then answered additional questions related to their projects (e.g., how many independent variables their project included, how many levels each independent variable included, what they planned to use as their dependent variable). I required students to calculate the effect size of a statistical test reported in a previous article that was relevant to their research project. I also instructed students to

use that effect size in conducting a power analysis for their project, as well as to conduct three additional power analyses with small, medium, and large effect sizes (holding the significance level at .05 and power at .80). I provided students in the class that received the GPOWER demonstration with instructions on how to download the calculator from the Internet. During the following week, I discussed the homework assignment with each class. Students then evaluated the power analysis lab. Finally, I introduced GPOWER to the students in the class that had not received the demonstration the week prior. All students received the same amount of credit for the homework assignment as it was graded as pass or fail.

Results

I conducted a power and sample size analysis for this study. With a large effect size ($d = .80$), alpha level = .05, and power = .80, the total number of participants needed to demonstrate a statistically significant effect in the current study was 42. However, because the actual number of participants totaled 47, the actual power of each t test was .85.

On average, students from the class without the GPOWER demonstration (M = 2.08 min) and students from the class with the GPOWER demonstration (M = 2.33 min) did not differ in their reports regarding the amount of time it took to complete

Table 1. Student Evaluations of the Power Analysis Lab and Homework Assignment

Evaluative Item	With GPOWER[a]		Without GPOWER[b]		
	M	SD	M	SD	t(45)
The Power Analysis Lab was appropriate for this course.	6.25	0.94	5.73	1.28	1.55
I now understand how to determine the number of participants I will need for my research project.	5.87	1.30	4.47	2.15	2.70*
The Power Analysis Lab increased my interest in my project.	4.40	1.38	3.43	1.56	2.48*
I would recommend using the Power Analysis Lab in future sections of this course.	5.75	1.29	4.86	1.79	1.94*
I would run a power analysis for my future research projects.	5.58	1.28	4.78	1.93	1.68
The GPOWER calculator was user-friendly and easy to learn how to use.	6.54	0.72	—	—	– – –
The GPOWER calculator helped me to learn how to use power analysis to determine the number of participants I would need for an experiment.	6.33	0.96	—	—	– – –
I think the GPOWER calculator is a useful way to learn about power analysis.	6.12	0.99	—	—	– – –
I would recommend using the GPOWER calculator to determine the number of participants needed for an experiment.	6.54	0.78	—	—	– – –

Note. Students rated items on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).
[a]$n = 24$. [b]$n = 23$.
*$p < .05$.

the power analysis section of the homework assign-ment, $t(45) = 1.35$, *ns*. The two classes did not appear to differ in their ability, as there was no difference between their average, overall grades for the course, $t(45) = .19$, *ns*. Evaluations of the power analysis lab and GPOWER appear in Table 1. In general, students of both classes reported that the power analysis lab was appropriate for the course. However, GPOWER students reported that they had a greater understand-ing for how to determine the number of participants needed for their research projects and a stronger endorsement for using the power analysis lab in future sections of the course than did students who did not receive the introduction to the GPOWER calculator. GPOWER students also reported that the power analy-sis lab increased their interest in their research projects more than non-GPOWER students. GPOWER stu-dents failed to report a significantly greater likelihood of conducting a power analysis for their future projects than the non-GPOWER students; however, the means were in the direction expected.

Students reported that the GPOWER calculator was user friendly and that it was helpful in determining the number of participants they might need for their project. These students also reported that the calcula-tor was a useful way to learn about power analysis and that they would recommend using the calculator for determining how many participants they would need when conducting an experiment.

Discussion

Each specific research design is associated with a unique set of equations to determine the necessary sam-ple size. It is unlikely that research methods instructors have the time necessary to teach students power anal-ysis procedures for each of the commonly employed research designs. Using a power analysis calculator can make the process of teaching power analysis easier by reducing some of the technical detail and still provid-ing students with a solution for a wide range of power analysis inquiries.

This investigation highlighted the usefulness of a computer-based power analysis calculator and a home-work assignment. In general, students appreciated the utility of the GPOWER homework assignment and en-dorsed the power analysis lab and assignment and its use in future sections of research methods courses.

GPOWER is very easy to use, but it is important that faculty do not replace standard instruction with "computer-substituted instruction." A general under-standing of the basic components to power analysis is a prerequisite to understanding GPOWER's full po-tential. For instructors who use GPOWER to assist in the instruction of power analysis, it is essential to first provide students with clear definitions of the essential components of power analysis.

A power analysis is an important step in the process of research. Wilcox (1998) suggested that the number of interesting findings lost to insufficient use of statistics is alarming. Perhaps this concern can be reduced by adopting efficient ways to reintroduce power analysis into the undergraduate psychology curriculum.

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Notes