

CAN A THREE-DAY INTENSIVE STATISTICS BOOT CAMP INCREASE GRADUATE STUDENTS' CORE KNOWLEDGE AND SELF-EFFICACY?

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Given our experience with graduate students' unpreparedness for their intermediate statistics course, we developed an intense three-day statistics refresher "boot camp," a type of bridge course. In this study we explored the impact of the boot camp on students' introductory statistics knowledge and self-efficacy towards introductory statistics concepts knowledge. Boot camp participants experienced an average increase of 10% in statistics knowledge and 18% in self-efficacy scores. After enrolling in their intermediate graduate statistics course, boot camp participants were found to have higher statistical knowledge and self-efficacy scores compared to their non-boot camp classmates.

INTRODUCTION

In the teaching of statistics, there is a documented relationship between non-cognitive (i.e., attitudinal or affective) factors and students' ability to learn (Gal & Ginsburg, 1994). For example, self-efficacy for mathematics has been more strongly predictive of academic performance than prior experience with mathematics (Pajares, 1996). Statistics self-efficacy has also been negatively related to factors that may impede students' ability to learn, such as statistics anxiety (e.g., Finney & Schraw, 2003; Onwuegbuzi & Wilson, 2003). Consequently, a variety of strategies have been employed to promote students' self-efficacy and academic success, one of which is the bridge course.

In the current study, we examined the effect of a bridge course on students' statistical self-efficacy and knowledge of elementary statistical concepts. Bridge courses, occasionally referred to as "boot camp" courses in the United States, are typically short courses designed to develop students' prerequisite skillset prior to entering a program. These brief, but intensive, courses have been linked to an increase in student self-efficacy (Johnson & O'Keefe, 2016; Shreiber, Moghe, & Roth, 2015; Stefan, Gutlerner, Born, & Springer, 2015). In particular, Shreiber and colleagues (2015) found a two-day boot camp at the beginning of an undergraduate research experience increased students' confidence in biotechnology and bioengineering.

Bridge courses have also been consistently linked to gains in self-efficacy and post-secondary education achievement. For example, first-year chemistry students had higher achievement scores after attending a seven-day intensive bridge course (Schmid, Youl, George, & Read, 2012). Senior medical students' clinical skills were higher after participating in a two-day simulation-based short course compared to historical trends (Wayne et al., 2014). Bridge course attendees showed a higher appreciation for the development of their skills after attending intensive short courses (Gordon & Nicholas, 2013).

Despite consistent findings in support of the effectiveness of bridge courses in promoting self-efficacy and achievement, there has been some evidence to the contrary. For example, entering life sciences doctoral students who participated in a short intensive course had no significant skill advantage compared to students did not participate (Feldon et al., 2017). In an eight-week intensive bridge course, health science students' knowledge of statistical concepts was weaker compared to students who received distributed practice of the same material over the course of six months (Budé, Imbos, van de Wiel, & Berger, 2011). In sum, despite evidence for their effectiveness, the utility of bridge courses is still debated.

Bridge courses have traditionally been used to teach *new* material through high intensity, short duration instructional methods. Contrary to previously developed short courses, we offered a boot camp as a short, high intensity *refresher* bridge course. Our fast-paced review session covered prerequisite material for students enrolled in an upcoming intermediate statistics course. We

examined the effectiveness of the three-day boot camp on two outcomes: basic statistics knowledge and statistics self-efficacy.

METHODS

Participants and Procedure

Boot camp participants ($n = 20$) and non-participants ($n = 13$) were graduate students enrolled in an *Intermediate Inferential Statistics* course scheduled to begin the following week. The free three-day boot camp was led by a doctoral level teaching assistant and two faculty instructors. Throughout the boot camp, evidence-based cooperative learning techniques, along with frequent metacognitive checks with immediate feedback, were employed to enhance student learning (e.g., Felder & Brent, 2016; Garfield, 1993; Halpern, 2004). Boot camp course content aligned with *prerequisite* elementary statistics knowledge for the intermediate statistics course. Topics included measures of central tendency, measures of variability, frequency graphs, z scores, the normal distribution, the sampling distribution of the sample mean, introduction to hypothesis testing, and p -values. Financial support for the boot camp came from a 4-VA Collaborative Research grant.

Participants completed a basic statistics knowledge assessment and a statistics self-efficacy assessment at the beginning (pretest) and end of the boot camp (posttest). Specifically, because the boot camp was held the week prior to the semester-long course, the posttest was administered to all students on the first day of their intermediate course. Doing so enabled data collection from a posttest comparison group consisting of students who did not participate in the boot camp.

Measures

Basic Statistics Knowledge. The 25-item multiple-choice assessment was created by boot camp facilitators to assess student knowledge of basic statistical concepts. Item difficulties ranged from .14 to 1.0. Internal consistency reliability (coefficient alpha) estimates were .74 and .67 on the pretest and posttest, respectively.

Current Statistics Self-Efficacy (CSSE). The CSSE was developed to measure students' current self-efficacy for performing basic statistics tasks (Finney & Schraw, 2003). Students responded to 14 Likert-scaled items on a scale of 1- *no confidence at all* to 6- *complete confidence*. Pretest and posttest internal consistency reliability estimates were above .95.

RESULTS

Statistical Knowledge. Participants' average basic statistical knowledge increased from 15.6 ($SD = 4.04$) to 17.95 ($SD = 3.45$) points. Non-participant average knowledge scores were nearly two points lower ($M = 16.00$, $SD = 3.29$) than participants' posttest scores. Participants' item-level percent correct scores rose from pretest to posttest. Non-participant item-level percent correct scores were nearly equivalent to participant pretest levels. Consider the two items displayed in Figure 1. Only 30% of boot camp attendees correctly responded to the first item (top) prior to boot camp. However, after the boot camp, 70% of attendees selected the correct response. Only 23% of non-participants correctly answered the item. For the second item displayed (bottom), only 46% non-participants correctly answered the questions, whereas participants' scores rose from 45% on the pretest to 60% on posttest.

Self-efficacy: Figure 2 displays the average change in statistical self-efficacy scores for participants on the 1-6 scale. Boot camp attendees experienced an average increase in statistics self-efficacy on all topics assessed. Participants evidenced the largest average self-efficacy increases when distinguishing between the three measures of central tendency (1.5 points), distinguishing between descriptive and inferential statistics (1.3), and when interpreting a p -value (1.3). The lowest self-reported efficacy was in the areas of power, selection of correct statistic, and explanation of standard error.

Large increases in self-efficacy did not necessarily coincide with large increases in statistical knowledge. For example, participants correctly interpreted a p -value 40% of the time on the pretest. This percentage increased only 5 percentage points after the boot camp (i.e., posttest), even though self-efficacy rose nearly 40% (1.3 points).

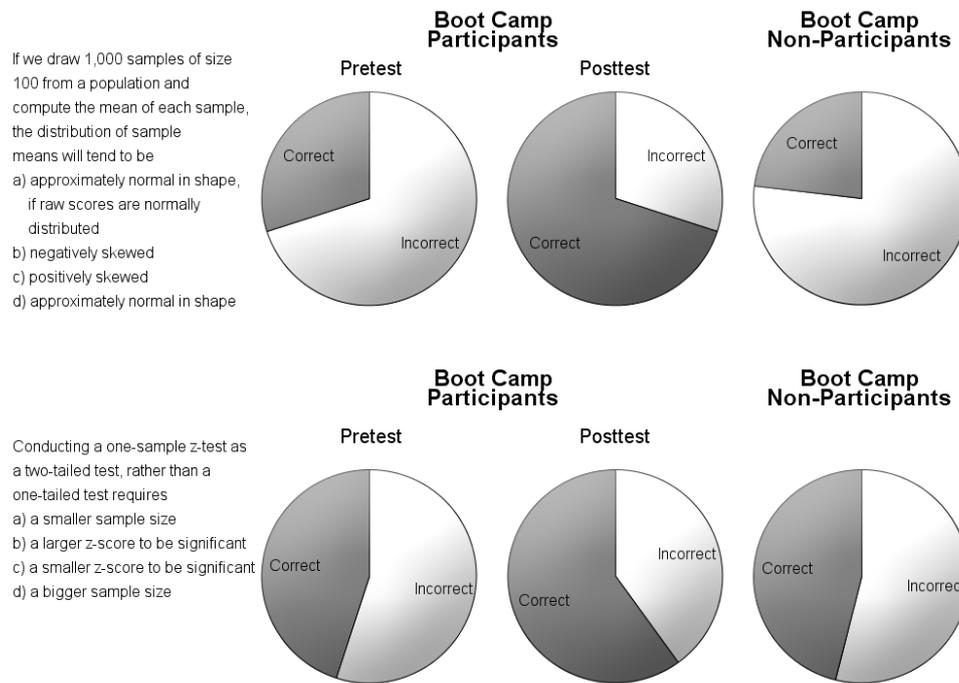


Figure 1. Item percentage correct scores for two items by boot camp participants (pre- and posttest) and Boot Camp non-participants.

Non-participant average self-efficacy scores for each topic are projected on Figure 2 using an “X”. Initially, participants reported lower average self-efficacy than non-participants. After the boot camp, participants reported higher self-efficacy than non-participants on all topics except two: 1) when explaining the differencing between a sampling distribution and a population distribution; and 2) selecting the correct statistic.

Participant posttest average self-efficacy was only slightly higher than non-participant self-efficacy for three topics (see Figure 2). However, these slight differences in self-efficacy were associated with large differences in knowledge. For example, consider an item on measures of central tendency, “A distribution can have more than one a) mean b) variance c) mode d) median”. Although non-participants had slightly lower self-efficacy scores (4.69 vs. 4.75), only 77% of non-participants correctly selected mode versus 95% of participants post boot camp.

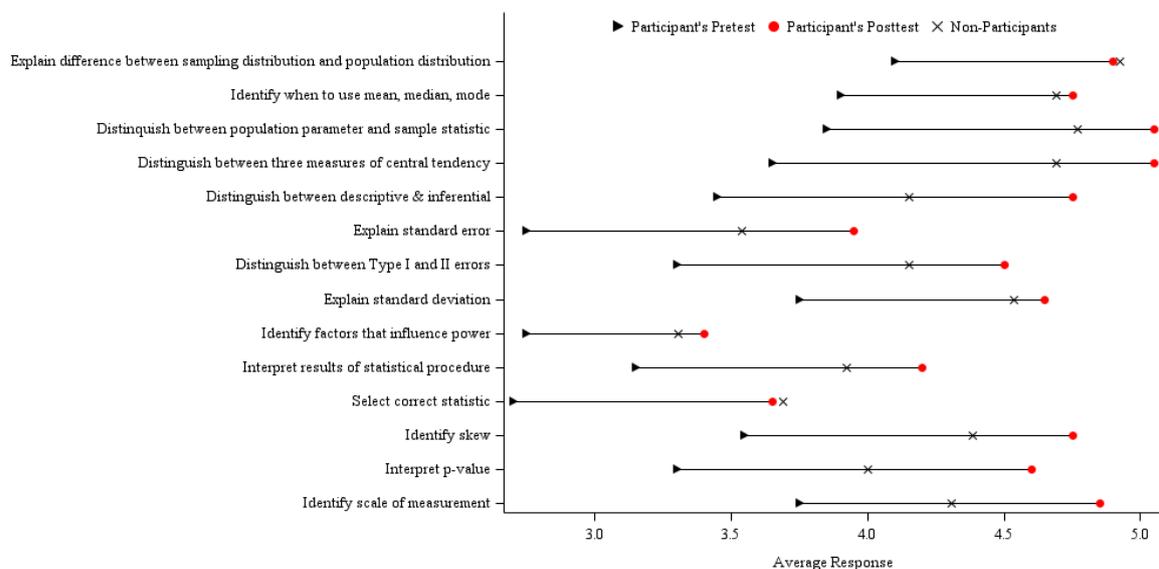


Figure 2. Pre- and posttest participant and posttest non-participant self-reported self-efficacy

CONCLUSION

We instituted a refresher style statistics graduate-level bridge course, a boot camp, for students enrolled in an upcoming intermediate statistics course. Participants' basic statistical knowledge increased. Furthermore, boot camp participants' statistical self-efficacy increased on every topic assessed. The most growth in self-efficacy occurred on topics emphasized by facilitators. These topics included material considered foundational, such as measures of central tendency and the interpretation of a p -value. Students experienced the least growth in self-efficacy on topics (e.g., power) facilitators did not cover in the boot camp providing validation to the study. Further evidence of boot camp effectiveness was displayed through participants' higher levels of self-efficacy and statistical knowledge compared to non-participants. Future studies will investigate factors, such as the maintenance of knowledge and skills over time (e.g., third time point) and the contribution of additional non-cognitive factors, such as statistics anxiety.

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