## Screencast Tutorials Enhance Student Learning of Statistics

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# Screencast Tutorials Enhance Student Learning of Statistics

**Steven A. Lloyd**[1] **and Chuck L. Robertson**[1]

**Abstract**

Although the use of computer-assisted instruction has rapidly increased, there is little empirical research evaluating these technologies, specifically within the context of teaching statistics. The authors assessed the effect of screencast tutorials on learning outcomes, including statistical knowledge, application, and interpretation. Students from four sections of a psychology course in statistics were randomly assigned to a control text tutorial or an experimental video tutorial group and were tasked with completing a novel statistics problem. Previous math experience, math and computer anxiety, and course grades were also controlled. The results demonstrate that screencast tutorials are an effective and efficient tool for enhancing student learning, especially for higher order conceptual statistical knowledge compared to traditional instructional techniques.

**Keywords**

statistics, screencasting, vodcasting, podcasting

According to the U.S. Census Bureau (2009), 73.5% of people 3 or older live in a household with Internet access, with a rising trend in the use of mobile media devices (61%) and podcast downloading (27%) for people 18–29 (Madden & Jones, 2008), and more than 80% of college students in the United States own at least one portable audio system capable of downloading audio and sometimes video files (Lum, 2006). In addition, the use of classroom technology, including podcasting, vodcasting, and screencasting, is on the rise in higher education. Some institutions have wholeheartedly embraced this technology and have launched massive campaigns to incorporate podcasting into the curriculum with demonstrated success (Fernandez, Simo, & Sallan, 2009).

Podcasting describes a form of downloadable audio files compatible with MP3 players that has been used for many years by institutes of higher learning to deliver or rebroadcast course content and/or supplemental materials (Donnelly & Berge, 2006; Hammersley, 2004). It is associated with numerous positive learning outcomes affecting a wide range of learners across a number of educational settings (i.e., enhanced learning, increased satisfaction, motivation and engagement, and positive impacts on course-related attitudes and anxiety reduction; Evans, 2008; Hew, 2009; McKinney, Dyck, & Luber, 2009).

Technological developments and increased accessibility to the Internet and mobile media devices coupled with increased software usability and institutional support have led to rapid developments in computer-assisted instruction on college campuses (Campbell, 2005). Therefore, the use of traditional podcasting in the classroom is being replaced by enhanced podcasting and vodcasting, which provide expanded media options for delivering course content. These forms of media are available on demand to mobile media devices, creating a new form of portable learning (i.e., m-learning) that has the advantage of expanding "the space" in which learning takes place (Donnelly & Berge, 2006).

There is a large gap between learning theory and teaching practices, which is especially evident when the research involves technological innovations directed toward college students (Fernandez et al., 2009). This gap is evident from the paucity of empirical research evaluating the impact of technologies on learning (Fernandez et al., 2009; Hew, 2009), specifically within the context of teaching statistics (Garfield & Ben-Zvi, 2007).

There are special issues to consider when teaching statistics to undergraduate students. In addition to heightened anxiety toward math, students resist learning statistics, reporting that it is difficult and not applicable to their chosen career. This is particularly troubling since negative cognitions and affect are related to statistics performance (Feinberg & Halprin, 1978) and given the importance of learning advanced concepts and the application of statistical knowledge for the undergraduate psychology major (American Psychological Association, 2007).

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The GAISE Report and the National Science Foundation provide suggestions for teachers of statistics geared toward specific learning goals, including promoting statistical literacy and thinking, using real data, promoting active learning, using technology for developing concepts and analyzing data, and using varied assessment (Franklin & Garfield, 2006; Hall & Rowell, 2008). Computer-assisted instruction and web-based technologies can promote active, task-based learning as well as student independence and conceptual learning in statistics, especially when they are grounded in cognitive learning theory (Lovett & Greenhouse, 2000; U.S. Department of Education [DOE], 2009).

Screencasting, defined as capturing what you do on the computer screen with synched audio commentary (Udell, 2004), is a real-time format that can be disseminated as enhanced podcasts or vodcasts and provides a medium for demonstrating algorithms for problem solving, software instructions, and errors while also providing interpretation-based conceptual understanding in an active learning format. Screencasting encourages meaningful learning according to the cognitive theory of multimedia learning, which suggests that multimodal information presented as combinations of narration and animation, when appropriately temporally and spatially sequenced, self-paced, coherently communicated, and stated in a conversational manner, leads to problem-solving transfer in novel situations and encourages active cognitive processing and cognitive load reduction to promote deeper learning (Mayer, Fennell, Farmer, & Campbell, 2004; Mayer & Moreno, 2003).

Given the need for empirical research on new instructional technologies, specifically within the context of statistical instruction, we set forth to determine the impact of a supplemental vodcast tutorial, which was designed according to multimedia learning theory recommendations, on objective learning outcomes in reference to statistical knowledge, application, and interpretation. Our results reveal that vodcasting is an effective and efficient tool for enhancing student learning, especially for higher-order conceptual statistical knowledge.

# Method

## Participants

A total of 53 students from four sections of an upper level psychology course in statistics participated. Stratified randomization was used to assign participants to experimental conditions based on gender. The sample consisted of predominantly young (R = 20–50, $M = 23.45$, $SD = 4.83$), Caucasian (91%, $n = 48$), upper level (junior or senior class status; 100%, $n = 53$), female (81%, $n = 43$) psychology majors (81%, $n = 43$) from a public university in the southeastern United States. All participants had taken a prerequisite course in elementary statistics, but the groups did not differ in the number, type, or level of additional math courses they had taken or completed ($p > .05$).

All procedures were performed in accordance with the university's institutional review board guidelines.

## Materials and Procedures

*Psychological scales.* A 10-item Math Anxiety Scale (MAS; Betz, 1978) and a 6-item Computer Anxiety Scale (CAS; Lester, Yang, & James, 2005) were administered during the first week of the semester.

*Screencast tutorials.* A screencast tutorial was created using iShowU (www.shinywhitebox.com) and iMovieMaker and was served as a vodcast. The tutorial demonstrated the following steps of statistical analysis: data entry, conducting an independent samples *t* test analysis, and working with output files in SPSS. The completed tutorial was 11.55 min in length. The control group was given a packet of material taken from an SPSS user guide, which covered the same content and included screen shots of the same SPSS environment demonstrated in the screencast tutorial (Kirkpatrick & Feeney, 2006). Participants in both groups were given 12 min to review their tutorials.

*Statistical problem set.* The statistical problem set necessitated an independent samples *t* test analysis. The raw data were listed, and the participants performed analyses using SPSS (v. 16.0). They were given 25 min to complete the task in Experiment 1. In Experiment 2, the time allotted to complete the task was increased to 55 min, and participants were allowed to review the video or text tutorial at the time of testing.

*Scoring the statistical problem set.* There were 10 possible points for this exercise. A point was awarded for correctly reporting the mean (Group 1), standard deviation (Group 1), mean (Group 2), standard error of the mean (Group 2), standard error of the mean difference score, *t* obtained, and *p* value. A point was also awarded for correctly rejecting the null hypothesis, using the correct reporting format, and stating the correct conclusion. Screencapture and mousecapture (iShowU) were used to record participants as they solved the problem. The number of mouse clicks executed and the time to complete the assignment were extracted from these recordings.

# Results

## Experiment 1

The experimental group did not differ in self-reported computer anxiety, $t(29) = 0.886$, $p = .383$, or math anxiety, $t(29) = 0.190$, $p = .851$, as measured by the CAS and the MAS, respectively. Although the MAS scores were positively correlated to CAS scores, $r(29) = .385$, $p = .032$, neither the MAS score, $r(29) = -.198$, $p = .287$, nor the CAS scores, $r(29) = .009$, $p = .963$, were correlated with final course grades.

The screencast tutorial group took less time to complete the statistical problem ($M = 15.20$, $SE = 0.70$) than the text tutorial group ($M = 18.06$, $SE = 0.67$), $t(29) = 2.950$, $p = .006$ (Figure 1). The screencast tutorial group also scored higher on the statistical problem set ($M = 7.27$, $SE = 0.30$) than did the text tutorial group ($M = 4.5$, $SE = 0.55$), $t(29) = 4.347$, $p < .001$ (Figure 2). In addition, the time to task completion

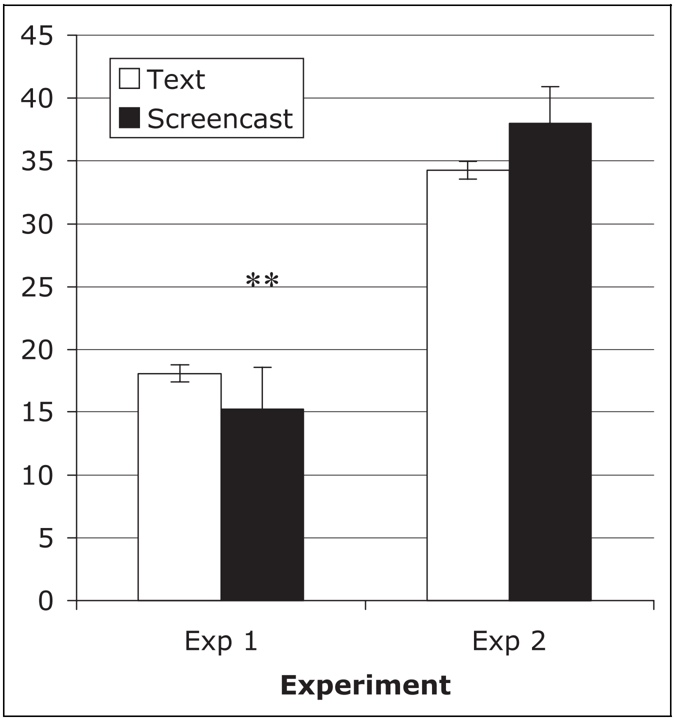


**Figure 1.** Total time to complete a statistics exercise (min) for each treatment condition and for each experiment
Error bars represent standard error.
**p* < .05. ***p* < .01. ****p* < .001

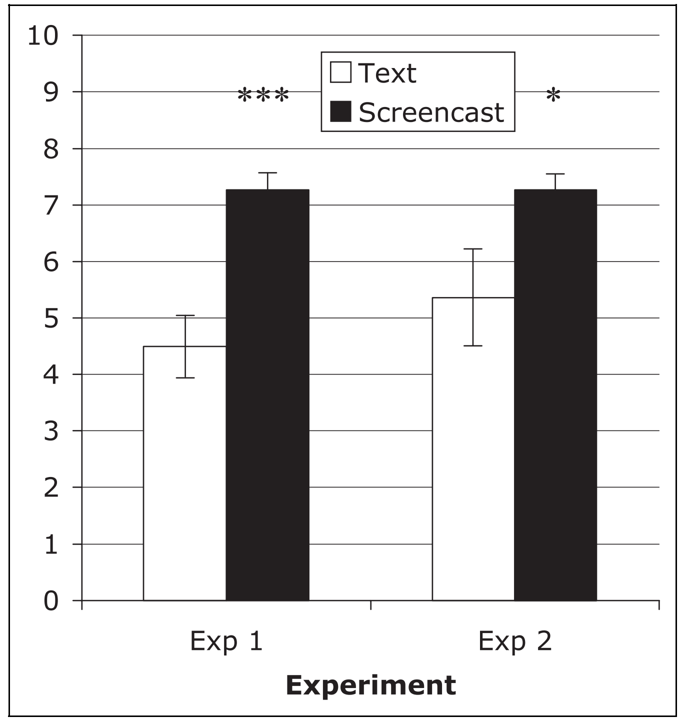


**Figure 2.** Total score on a statistics exercise (out of 10 points) for each treatment condition and for each experiment
Error bars represent standard error.
**p* < .05. ***p* < .01. ****p* < .001

negatively correlated with total score on the problem set, $r(29) = -.510$, $p = .003$.

The screencast tutorial group outscored the text tutorial group on several individual questions, including correctly stating the mean (Group 2; $M = 1.00$, $SE = 0$ and $M = 0.75$, $SE = 0.11$, respectively), $t(29) = 2.163$, $p = .039$, the $t$ obtained ($M = 1.00$, $SE = 0$ and $M = 0.38$, $SE = 0.13$, respectively), $t(29) = 4.836$, $p < .001$, the $p$ value ($M = 0.73$, $SE = 0.12$ and $M = 0.25$, $SE = 0.11$, respectively), $t(29) = 2.973$, $p = .006$, and the standard error of the mean difference score ($M = 1.00$, $SE = 0$ and $M = 0.50$, $SE = 0.13$, respe\ctively), $t(29) = 3.746$, $p = .001$, and correctly rejecting the null hypothesis ($M = 0.47$, $SE = 0.13$ and $M = 0.06$, $SE = 0.06$, respectively), $t(29) = 2.802$, $p = .009$ (Table 1). The ability to correctly reject the null hypothesis was positively correlated with the total score on the problem set, $r(29) = .412$, $p = .021$.

## *Experiment 2*

Given additional time to solve the problem (55 min vs. 25 min in Experiment 1) and the ability to review the video or text tutorial at the time of testing, the screencast group ($M = 7.27$, $SE = 0.27$) outperformed the text tutorial group ($M = 5.36$, $SE = 0.85$), $t(20) = 2.15$, $p = .044$ (Figure 2), but the time to task completion did not differ between the video group ($M = 38.00$, $SE = 2.92$) and the text group ($M = 34.27$, $SE = 3.33$), $t(20) = 0.841$, $p = .41$ (Figure 1). Differences in specific test questions included the ability to correctly state the value of $t$

**Table 1.** Experiment 1

| | | Screencast | | Text | | | |
|---|---|---|---|---|---|---|---|
| Measure | *N* | *M* | *SE* | *M* | *SE* | *t*(29) | *p* |
| Time to complete (min) | 31 | 15.2 | 0.70 | 18.06 | 0.67 | 2.95 | .006 |
| Total score (out of 10) | 31 | 7.27 | 0.30 | 4.5 | 0.55 | 4.35 | <.001 |
| Specific questions[a] | | | | | | | |
| Correct Group 2 mean | 31 | 1.00 | 0 | 0.75 | 0.11 | 2.16 | .039 |
| Correct *SE* of the *M* difference | 31 | 1.00 | 0 | 0.53 | 0.52 | 3.75 | .001 |
| Correct *t* value | 31 | 1.00 | 0 | 0.38 | 0.13 | 4.84 | <.001 |
| Correct *p* value | 31 | 0.73 | 0.12 | 0.25 | 0.11 | 2.97 | .006 |
| Correct rejection of null | 31 | 0.47 | 0.13 | 0.06 | 0.06 | 2.80 | .009 |

a. *Correct response* = 1, *incorrect response* = 0.

obtained, $t(20) = 2.39$, $p = .027$, and the standard error of the mean difference score, $t(20) = 2.39$, $p = .027$ (see Table 2).

The most efficient strategy to solve the statistical problem was predetermined. Neither the video tutorial group ($M = 229.80$, $SE = 26.14$) nor the text tutorial group ($M = 228.67$, $SE = 29.81$) used efficient strategies, nor did they differ from one another, $t(20) = 0.029$, $p = .98$.

## Discussion

Despite the rise in online instruction, there are few empirical, methodologically sound studies assessing web-based

**Table 2.** Experiment 2

| | | Screencast | | Text | | | |
|---|---|---|---|---|---|---|---|
| Measure | *N* | *M* | *SE* | *M* | *SE* | *t*(20) | *p* |
| Time to complete (min) | 22 | 38.00 | 2.92 | 34.27 | 3.33 | 0.84 | >.05 |
| Total score (out of 10) | 22 | 7.27 | 0.27 | 5.36 | 0.85 | 2.15 | .044 |
| Specific questions[a] | | | | | | | |
| Correct Group 2 mean | 22 | 1.00 | 0 | 0.91 | 0.09 | 1.00 | >.05 |
| Correct *SE* of the *M* difference | 22 | 1.00 | 0 | 0.64 | 0.15 | 2.39 | .027 |
| Correct *t* value | 22 | 1.00 | 0 | 0.64 | 0.15 | 2.39 | .027 |
| Correct *p* value | 22 | 0.73 | 0.14 | 0.36 | 0.15 | 1.75 | >.05 |
| Correct rejection of null | 22 | 0.45 | 0.16 | 0.09 | 0.09 | 2.00 | >.05 |

a. *Correct response* = 1, *incorrect response* = 0.

technologies in the classroom (DOE, 2009). Our study adds to this modest literature by demonstrating positive learning gains for students using a supplemental screencast tutorial in an undergraduate statistics course, especially on higher-order conceptual knowledge involving statistical literacy and the application of statistical knowledge to draw inferences about the data. Our findings are in line with those of Basturk (2005), who showed learning gains after computer-assisted instruction using SPSS, especially for inferential statistics.

The participants in Experiment 1 and Experiment 2 differed in the amount of time they had to complete the problem set. The screencast tutorial group performed at a similar level, albeit significantly higher than the text tutorial group, regardless of time on task. The text tutorial group improved with expanded time, but significant differences were still apparent in their ability to apply some higher-order conceptual knowledge of statistics. The groups did not differ in time spent solving the problem set in Experiment 2, but both groups spent more time completing the problem set in Experiment 2 than they did in Experiment 1.

According to the cognitive theory of multimedia learning, the mind is a dual-channel, limited-capacity, active processing system, which benefits from learning strategies utilizing cognitive load reduction and multimodal learning, especially for semantic memory encoding and accessibility for working memory in problem-solving transfer (Mayer, 2001). Automaticity, increasing what you know about the topic, and developing and working through a systematic plan also improve problem solving (Ashcraft, 2006). Empirical evidence supports a multimedia effect for retention and problem-solving transfer (Mayer, 2001) with a potential to help the learner develop correct conceptual mental models (Alessi & Trollip, 2001) and analogies for problem solving (Leighton & Sternberg, 2003) and suggests that additional time on task reduces one or more cognitive barriers through the use of multimodal media. However, we show that the use of screencast tutorials remained beneficial over the text tutorials regardless of time on task. When granted more time on the task, the screencast tutorial group performed an equal number of mouse clicks as the text tutorial group, but neither group used efficient strategies. These data suggest that the video tutorial group were not just following algorithms based on rote memorization but that their demonstrated enhanced learning arose from better conceptual understanding and problem-solving transfer.

This study provides support for the use of computer-assisted technology in teaching statistics to undergraduate psychology students. These results are extremely relevant given the challenges that instructors face in teaching statistics, especially considering its importance in the undergraduate psychology curriculum. Future studies should consider whether the use of vodcasting provides the same benefits when used to supplement an entire course, perhaps in out-of-class, nonproctored labs or asynchronous online environments.

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