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Soft Circuits: Improving Attitudes Toward Circuits Through Crafternoons

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Historically, STEM fields (science, technology, engineering, and mathematics) have shown to be less appealing to girls and women. In an attempt to appeal directly to females learning the science of circuits, Utah State University added a new soft circuits lab involving sewing circuits using conductive thread. Building upon the work of the Georgia Tech computing camps, attitude changes due to this soft circuits lab were studied. A Utah State University physics course for elementary education majors comprised the test group. The test group was largely comprised of females, who as a whole showed a significant positive response to building circuits through craft activities.

1 Introduction

In 2011, B. Ericson and T. McKlin reported on the effectiveness of the computing summer camps held by Georgia Tech. The focus of the summer camps were to “improve access to computing, increase students’ knowledge of computing concepts, and change students’ attitudes about computing” [CITE]. The camp covered a number of activities designed for students ranging from elementary to high school. Overall positive results were reported in the change in attitudes toward computing projects.

To further the work done at Georgia Tech, a Utah State University physics course was chosen to test the change in attitude at the university level for one particular project used at the Georgia Tech camps. The class chosen for participation was PHYS 1200: Physics by Hands-on Exploration, a physics course tailored to students majoring in elementary education. This particular group presented a unique testing group for physics classes in the sense that a large portion of the class is female.

The activity chosen was Soft Circuits, an integration of circuit building and sewing. It was

modeled after projects found in a circuits craft book, Sew Electric [1]. The activity was implemented in a required lab for the course, however, students voluntarily and anonymously took part in the attitude survey before and after the lab. The lab requirement was to show a knowledge of circuits by utilizing conductive thread to connect a small power source to small LED lights [2]. The LED must light up to show a working circuit was built. The students were asked to show this knowledge later through an exam question given in the class. The question of note asked students to draw a diagram of what they did in the circuits lab, including labeling positive and negative connections, wire configuration (i.g. not crossing wires anywhere to short the circuit). Though the students just needed a working circuit for full credit, most students took the opportunity to be a bit more creative and work on something more challenging.

2 Survey

To provide numeric data on a change in attitude, the students were asked to answer a survey before and after the circuits lab.

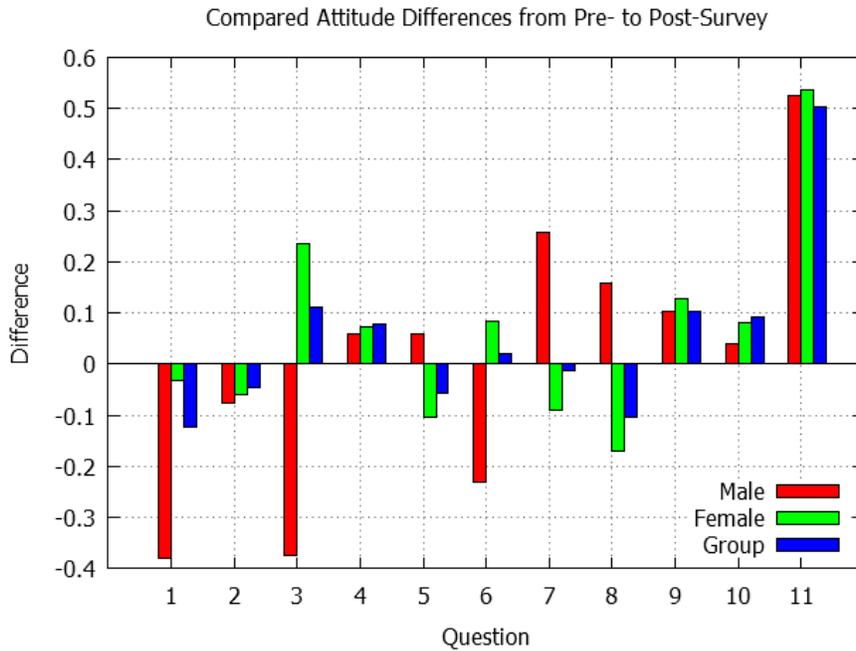


Figure 1: A comparison of the differences as sorted by gender and the group as a whole. The most consistent change in opinion between groups occurs with Question 11.

The survey for both were identical. On the survey the students were asked to rate their agreement with some given statements. The answers allowed were on a Likert scale that ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). The survey was based upon the questions asked at the 2011 Georgia Tech computing camp, with some changes instituted to fit this particular survey. The survey consisted of the following questions (questions marked were not part of the Georgia Tech survey):

1. Computers are fun.
2. Programming is hard.
3. Craft projects like sewing are fun.*
4. Women would like jobs in computing.
5. Women can have jobs in computing.
6. Computer jobs are boring.
7. Women are better at craft projects than men.*
8. I am good at computing.
9. I know more than my friends about computing.
10. I have an excellent sense of fashion.*
11. I would like to wire a circuit.*

The main focus of the study in particular was

to note any significant change in attitude toward Question 11. The remainder of the questions were included as comparison data points, from which no significant change was expected. A majority of the questions were pulled from the Georgia Tech camp, which had a larger focus on computing than this lab on circuits. As such, there is little to suggest that there would be any change in opinion on those questions. The participants were also asked to identify their gender. With the information about gender, the data can be separated to look for gender bias in the opinions.

3 Results

The data were evaluated in two ways. First, the survey group as a whole was evaluated to see the change in attitude. Then, the responses were sorted according to gender in order to evaluate any gender differences in the change of attitude.

3.1 Entire Group

Table 1 denotes the averaged answers to each question as well as the difference between pre- and post-lab.

Q	Pre-Lab	Post-Lab	Difference
1	3.97	3.85	- 0.12
2	3.78	3.74	-0.05
3	3.63	3.74	0.11
4	3.50	3.58	0.08
5	4.53	4.47	-0.06
6	3.12	3.14	0.02
7	3.25	3.24	-0.01
8	3.04	2.94	-0.10
9	2.67	2.77	0.10
10	3.41	3.50	0.09
11	2.34	2.84	0.50

Table 1: Results of Survey Group

The data shown detail small changes in Questions 1 through 10, with Question 11 being notably higher. Significance of the differences are noted under Data Analysis.

3.2 Sorted by Gender

Table 2 Shows the differences in pre- and post-survey responses as separated by gender. These are discussed in the Conclusions section, but it can be noted here that there are differences between the male and female results.

3.3 Exam Question

As mentioned before, the students were required to show their knowledge of circuits on one question on an exam given in class. The problem was "Draw a sketch of a circuit including a battery and LED light bulb like you built in lab. Label polarity (+/-) of the battery and LED and how the wires must connect to make the light come on."

While grading this question, common mistakes were recorded. The most notable mistake made was reversed polarity (connecting a + to a -) on their sketch.

4 Data Analysis

To test the significance of the results, an unpaired t-test was applied to the differences. An unpaired

Q	Male	Female
1	-0.38	-0.03
2	-0.08	-0.06
3	-0.37	0.23
4	0.06	0.07
5	0.06	-0.10
6	-0.23	0.08
7	0.26	-0.09
8	0.16	-0.17
9	0.10	0.13
10	0.04	0.08
11	0.53	0.54

Table 2: Differences by Gender

t-test was chosen since the pre- and post-survey responses were anonymous, and thus unable to be paired specifically with one individual's pre- and post-survey responses. Equation 1 was used to determine the t value for each question in the survey. This utilized the means of the groups (\bar{x}_1, \bar{x}_2), the sample variance (s^2), and the sample size of the groups (n_1, n_2). The sample sizes for this particular group were $n_1 = 99$ responses for the pre-test and $n_2 = 133$ responses for the post-test.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s^2 \cdot \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}} \quad (1)$$

This t-value was then used along with statistical software to numerically solve for a two tailed p-value for each group (male, female, and entire group) per question. This method produced a single value of interest; the female group showed a p-value of 0.0009 for Question 11. The results for the control questions (Questions 1-10) behaved as predicted. For the entire group, the control questions produced p-values ranging between 0.26 and 0.93, showing no significance.

Similar results were revealed through the analysis of the group split into genders. For both male and female, Questions 1 through 10 had p-values which varied between 0.11 and 0.89, also showing no significance. For Question 11, the female group showed a p-value of 0.0009 (as mentioned before), suggesting extreme significance. However, the male group only showed a p-value

of 0.0676, which on its own is not quite significant.

5 Discussion

The end result showed a significant improvement in the attitudes toward circuits for both the entire group and the female group alone. However, the change in attitude for the male group did not show statistical significance. This suggests that the male component did not significantly alter the group as a whole when the responses from women was added. The comparison questions (Questions 1-10) also showed no significance

in attitude change. This, along with the significance found through the p-value for Question 11, suggests attitudes of female students were indeed changed for the positive due to the Soft Circuits lab activity.

Looking forward, the question will be if teachers actually utilize activities such as this in the classroom. As this was the first group to be tested, there is a minimum of four years before most of these students will be teaching in a classroom. This means it will be some time before the end results of this are apparent. The goal is to encourage and excite future teachers, and a review of their classroom approach to circuits may show that the goal was indeed reached.

References

- [1] Beuchley, Leah; Qiu, Kanjun; and de Boer, Sonja. *Sew Electric* HLT Press, Cambridge, MA 2013
- [2] Triplett, Tonya. *Lab Manual: Physics 1200*. Utah State University 2014