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# Exploring pre-service elementary teachers' engineering teaching efficacy beliefs (fundamental)

## Rebekah J Hammack (Assistant Professor)

Dr. Rebekah Hammack is an Assistant Professor of K-8 Science Education at Montana State University. She holds a bachelors in animal science from the Ohio State University, a masters in animal science from Oklahoma State University, and a doctorate in science education form Oklahoma State University. Prior to beginning her faculty position at MSU, she completed an Albert Einstein Fellowship within the Directorate of Education and Human Resources at the National Science Foundation and spent 12 years teaching science and engineering in rural and small town settings at the K-8 level. She is also a recipient of the Presidential Award for Excellence in Mathematics and Science Teaching. Dr. Hammack researches science and engineering teacher efficacy and student engineering identity development at the K-8 level.

## Ibrahim H. Yeter (Post Doctoral Researcher)

Ibrahim H. Yeter, Ph.D., is an Assistant Professor in the National Institute of Education (NIE) at Nanyang Technological University (NTU) in Singapore. He is currently an affiliated faculty member of the Centre for Research and Development in Learning (CRADLE) at NTU as well as the Director of the World MOON Project.

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## Abstract

With the introduction of the Next Generation Science Standards (NGSS, 2013) nearly a decade ago, engineering implementation in the K-12 setting has become significantly important to embed within existing curriculum and teaching practices. As efforts to prepare engineering knowledgeable teachers progress, there is a need for support in providing effective engineering concentrated instructions for preservice teachers. Such an attempt may eventually boost preservice teachers’ self-efficacy in teaching engineering practices. While some educational efforts have been made to support teachers, there is a lack of research on how to support effective engineering instruction in preservice elementary education. According to Gibson and Dembo (1984), the teaching efficacy represents a teacher's conviction that, despite external difficulties, any teacher can generate positive student learning results. Empirical studies suggest that teachers' beliefs have been demonstrated to influence their pupils' beliefs and academic achievements. Further, studies suggest that teachers who have higher self-efficacy should, in theory, be more self-confident and successful teaching. Additionally, recent studies suggest that exposing students at an early age to engineering practices may maintain their interests in science, technology, engineering, and mathematics (STEM) disciplines. The main purpose of this study is to explore which factors influence preservice elementary teachers’ teaching engineering efficacy. A convenience sampling technique was used to collect data from 144 preservice teachers (88% female, 12% male) enrolled in an elementary education bachelor’s degree program at a public university in the Rocky Mountain region of the United States. The 15-week-long course was offered in three different modalities: face-to-face, hybrid, and online. Participants were given an empirically validated (i.e., T-STEM) pre- and post-survey at the start and end of the semester in which they were enrolled in a K-8 science teaching methods course. The participants completed these instruments in a voluntarily based order with an estimated time of 20–25 minutes to finish the survey. Two-tailed paired sample t-test computed from the mean scores for each of the pre- and post-survey indicated the statistical significance of gains from pre- to post-instruction scores. The findings suggest that engaging in multiple, varied engineering components during a science methods course can boost preservice teachers’ engineering teaching efficacy across multiple course modalities.

## Introduction

The integration of engineering in the elementary education curriculum along with other subjects is extremely pertinent, especially considering that many current educators have not been trained to teach engineering (Banilower et al., 2018). Given that teachers often do not feel prepared or competent enough to teach engineering (Hammack & Ivey, 2017), it is essential for them to undergo training to boost their confidence levels and competence. Unfortunately, most teachers did not have access to coursework that focused on how to teach engineering during their teacher preparation programs (Banilower et al., 2018; Hammack et al., 2020; Hammack & Ivey, 2019), with teachers citing this lack of preparation as an influence on their lack of confidence or efficacy to teach engineering (Hammack & Ivey, 2019). Existing studies strongly suggest that teacher efficacy is one of the most influential components for effective instruction (e.g., Cakiroglu et al., 2012; Tschannen-Moran & Hoy, 2001), highlighting the importance of providing preservice teachers (PSTs) with opportunities to learn how to teach engineering during their college preparatory coursework. As such, researchers are beginning to identify strategies to help better prepare PSTs to be engineering teachers. For example, Fogg-Rogers, Lewis, and Edmonds (2017) found that PSTs had enhanced engineering teaching efficacy after participating in an engineering design process training and later teaching engineering to children in afterschool programs. Similarly, Perkins Coppola (2019) reported an increase in PSTs' engineering teaching efficacy after developing and teaching engineering lessons to K-5 students. These studies illustrate the value of having PSTs teach engineering lessons to children; however, this is not an option for many PSTs due to programmatic constraints on classroom placement, which often limit how long and what subjects they are able to teach. Therefore, it is important for researchers to explore other factors that can enhance engineering teaching efficacy for PSTs, especially when they do not have access to teach children. The purpose of the current study was to explore how infusing engineering learning opportunities into a science methods course (in the absence of teaching to children) impacts PSTs engineering teaching efficacy. Specifically, we sought to answer the following research questions:

(1) How does participating in a K-8 engineering-focused course impact preservice elementary teachers' engineering teaching efficacy?

(2) Are there differences in preservice teachers' engineering self-efficacy between demographic groups?

## Theoretical Framework: Self Efficacy

The self-efficacy of educators is something that has been consistently related to the attitude of educators and the outcomes of students (Colvin, Kame'enui, & Sugai, 1993). Bandura (1977), Berliner (1988), Daunic et al., (2006), and Henson (2001) found that educators who have high self-efficacy displayed various qualities such as patience, competence, and knowledge of how to use research-based practices to help students who may have deficiencies in certain skills. High teacher efficacy has been linked to higher student achievement outcomes, a willingness to be open to new teaching ideas, and persistence in the face of classroom challenges (Tschannen-Moran & Hoy, 2001). Additionally, Lewis-Moreno (2007) and Bandura (1977) found that educators with low self-efficacy can pass on their negative beliefs to their students, which can consequently discourage them and hinder their academic success. As such, educators' self-efficacy is vital in the management of classrooms, educational practices, and outcomes of learning.

Confidence and self-efficacy are pertinent for educators, especially to implement a curriculum integrated with engineering (Perkins Coppola, 2019). Pre-service educators (PSTs) may have to undergo training before the implementation of engineering in classrooms as firstly, they may not be able to define engineering and may have misconceptions about it (Pleasants &

Olson, 2019); secondly, lack knowledge about the subject (Avsec & Sajdera, 2019) and lastly, may not have experiences in teaching or learning the subject (Bir et al., 2017). As such, they may feel unprepared (Bir et al., 2017) and have a lower self-efficacy in teaching engineering, which can translate to students not being able to learn the subject successfully (Perkins Coppola, 2019). To ensure that PSTs are better prepared, many such as Aydeniz and Bilican (2018), Coppola (2019), Lin and Williams (2017), and Wendell et al. (2019) believe that they should be exposed to the engineering design process (EDP) so as to learn how to implement and teach projects related to engineering. As found by Dalvi et al. (2020), given that many PSTs may not have prior knowledge or experience in engineering, it is rather plausible that they may have misconceptions about the subject and thus misrepresent it in teaching. As such, some solutions to this would be to connect these PSTs with engineers or engineering students (Fogg-Rogers et al., 2017), expose PSTs to design projects in the engineering industry (Gibson, 2013) so that they gain some real world experience, and actually allow the PSTs to teach the students instead of merely planning the lessons (Aston & Jackson, 2009). This way, PSTs will gain a better understanding of what engineering is, gain and understand content knowledge, be more able to see things from a learner's perspective, and also understand the real-world applications of what they are teaching (Perkins Coppola, 2019; Kurup et al., 2019; MacGregor & White, 2016). These activities will thus boost educators' confidence and increase their self-efficacy, allowing for better implementation of engineering subjects in the classroom, and lesser misconceptions about the subject (Hanson et al. 2021).

Self-efficacy is affected by one's experience thus those with more experience with regards to engineering will likely have higher self-efficacy (Mohr-Scroeder & Thomas, 2015). Due to factors such as gender role socialization, which are usually brought about by parents and relatives during infancy, and due to expectations from parents which influence the children's perceptions of their capabilities (Eccles, 2007), females may have lesser opportunities to experience activities related to math and science as opposed to their male counterparts (Hyde, 2007). Existing studies (e.g., Hammack & Ivey, 2017) indicates that female teachers generally have lower engineering self-efficacy than male teachers. Furthermore, Went et al. (2015) found that some female teacher candidates may have limited engineering teaching efficacy due to the influence of gender norms and stereotypes. Moreover, educators may not approach content that they are not comfortable teaching (Brophy et al. 2008) which could hinder their implementation of engineering (Wendt et al., 2015). Additionally, Lee, Hsu, and Chang (2019) indicated that generally male educators perceived increased confidence as opposed to female educators. Prior research by Bong (1999) has also indicated that women are generally less confident in terms of engineering and technology-related areas compared with males, and women may also underestimate their abilities and interest in STEM due to gender stereotypes and societal ideologies that males may be more capable in such fields than females, which could result in females reporting lower self-efficacy (Lee et al., 2019). This is thus a reflection that there are indeed gender differences in teachers' efficacy related to engineering. This hence reflects that male teachers portrayed higher self-efficacy than female educators in terms of the STEM-related factors, including engineering, that were surveyed.

## Methodology

### *Participants*

Participants include 145 undergraduate students attending a large, land-grant university in the US mountain west. At the time of data collection, all participants were enrolled in a 15-week-long K-8 science methods course as part of an initial elementary teacher licensure program. Participants (n = 144) were predominantly female ($n_{female}$ = 125, $n_{male}$ = 17) and white ($n_{white}$ = 131, $n_{hispanic}$ = 4, $n_{NativeAmerican}$ = 2, $n_{asian}$ = 1, $n_{multiple}$ = 3). All students were juniors and seniors and had completed three college science courses (one life, one Earth, and one physical).

### *Data Collection*

To answer the research questions, the Engineering Teaching Efficacy and Beliefs (ETEB, 11 items) subscale from the Teacher Efficacy and Attitudes toward STEM (T-STEM) Survey was chosen (Friday Institute, 2012). The scale consists of statements that the participant must rank on a five-point Likert scale ranging from Strongly Disagree to Strongly Agree. An example item reads “I am continually improving my engineering teaching practice.” The T-STEM subscale items were entered into a Qualtrics form, along with demographic questions, and a link was given to participants through the university’s online course management system. Participants completed the pre-survey during the first week of their science methods course and completed the post-survey during the final week of their science methods course.

### *Course Structure*

The 15-week long course was focused on preparing elementary education majors to teach science at the K-8 level. While this was a science methods course, there were numerous classroom activities and assignments that focused on engineering, due to the presence of engineering in science standards at the national and state levels. Engineering focused activities included: (1) a 1.5-hour introduction to engineering design lesson using the Tower Power lesson from *Engineering is Elementary*; (2) a four-hour problem-based engineering design challenge that required students to design, create, and test devices that limit heat transfer; (3) a two-hour video case analysis assignment that required students to watch a series of video clips of engineering being taught in elementary classrooms and then analyze the engineering teaching practices they observed; (4) a one hour lesson focused on engineering with Kindergarteners through the design of shade structures; (5) a series of readings devoted to engineering design, engineering habits of mind, how to assess engineering lessons, and how to connect engineering to other disciplinary standards (i.e., math, language arts); and (6) creation of a 5E lesson that contained an engineering component. The course was presented in three different modalities, (1) face-to-face (2) hybrid, and rapid shift to online instruction. The face-to-face participants (n=71) had two 90-minute classes per week on campus for the duration of the 15-week semester. The hybrid participants (n=42) met on campus for six 90-minute classes (one class per week for the first six weeks of the semester) and completed the remainder of the coursework online, meeting every other week for 90-minutes of instruction on Webex. The rapid shift of online participants (n=31) completed the first seven weeks of the semester on campus, meeting in person for 180 minutes each week. After spring break, the remaining eight weeks of instruction were fully asynchronous due to a COVID-19 lockdown in Spring 2020.

### *Data Analysis*

We entered the ETEB data from all five semesters into an MS Excel document and analyzed the data from the 144 participants using SPSS v28. This data analysis process generated pre-ETEB and post-ETEB mean scores for each survey and then an average score for each survey was calculated. Two-tailed paired sample t-tests computed from the mean scores for each of the surveys indicated the statistical significance of gains from pre- to post-instruction scores.

## Results

Pre-service elementary teachers' engineering teaching efficacy was compared before and after taking an engineering-focused course. On average, pre-service elementary teachers performed better after ($M = 3.87$, $SD = 0.53$) the course than before ($M = 2.60$, $SD = 0.67$) the course (see Table 1). This improvement, 1.27, with a 95% confidence interval (CI) [1.14, 1.39], was statistically significant, $t(143) = 20.43$, $p < .001$ as shown in Table 2 and 3. These results suggest that the engineering-focused course really does have a positive impact on enhancing pre-service elementary teachers' engineering teaching efficacy.

Table 1. Paired samples statistics

| | | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Pre-Survey | 144 | 2.600 | 0.666 | 0.056 |
| | Post-Survey | 144 | 3.866 | 0.527 | 0.044 |

Table 2. Paired samples correlations

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Pre- and Post-Survey Average | 144 | 0.241 | 0.004 |

Table 3. Paired sample test

| | Paired Differences | | | 95% Confidence Interval of the Difference | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pre- & Post-Survey | 1.265 | 0.743 | 0.062 | 1.143 | 1.388 | 20.432 | 143 | 0.000 |

Engineering teaching self-efficacy scores for female and male participants were compared before and after the course engagement. On average, before engaging in the course, male PSTs (*M* = 3.02, *SD* = 0.58) performed better than female PSTs (*M* = 2.54, *SD* = 0.66). Similarly, after engaging the course, on average, male PSTs (*M* = 4.11, *SD* = 0.45) performed better than female PSTs (*M* = 3.83, *SD* = 0.52) (see Table 4). These differences for both before, -0.48, 95% CI [0.81, -0.14], and after, -0.28, 95% CI [-0.54, -0.15], the course engagement, were statistically significant, *t* (140) = -2.83, *p* < .005 and *t* (141) = -2.09, *p* < .038, respectively (see Table 5). It should be noted that the sample size for males (n = 17) is significantly less than females (n = 125).

Table 4. Group statistics (Gender)

| | Gender | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pre-survey | Female | 125 | 2.543 | 0.664 | 0.059 |
| | Male | 17 | 3.021 | 0.575 | 0.140 |
| Post-survey | Female | 126 | 3.830 | 0.519 | 0.046 |
| | Male | 17 | 4.107 | 0.453 | 0.110 |

Table 5. *Independent samples test (gender)*

| | | Leven’s Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference Lower | Upper |
| Pre-survey | Equal Variances assumed | 0.401 | 0.528 | 2.830 | 140 | 0.005 | -0.479 | 0.169 | -0.813 | -0.144 |
| | Equal Variances not assumed | | | 3.157 | 22.226 | 0.005 | -0.479 | 0.152 | -0.793 | -0.164 |
| Post-survey | Equal Variances assumed | 0.026 | 0.873 | 2.091 | 141 | 0.038 | -0.277 | 0.132 | -0.538 | -0.015 |
| | Equal Variances not assumed | | | 2.322 | 22.091 | 0.030 | -0.277 | 0.119 | -0.523 | -0.030 |

Additionally, multiple comparisons techniques were performed to explore statistical correlation between modality categories including face-to-face (F2F, n = 71), rapid shift online (n = 31), and hybrid (n = 42). Despite a considerable sample size for each setting, differences between modalities were non-significant in both pre- and post-survey. These results suggest that modality does not have a significant influence on pre-service elementary teachers’ engineering teaching efficacy. Detailed statistical outputs are provided in Table 6 and Table 7 in Appendix A.

Furthermore, reliability statistics were executed for both the ETEB pre- and post-surveys. As shown in Table 8, the values for Cronbach’s alpha were $\alpha = 0.887$ and $\alpha = 0.884$ for pre- and post-survey instruments, respectively. Both results clearly indicate the high reliability of the measuring instrument. Moreover, it denotes a high degree of internal consistency for the samples in the items. Additionally, the item-total statistics illustrate a construct's statement-by-statement accuracy (Table 9). It is critical to determine if all assertions accurately measure a feature. Therefore, item-wise statistics were administered. As shown in Table 9, the same item, TSTEM_ETEB_05 (i.e., I wonder if I have the necessary skills to teach engineering), indicates the weakest adjusted statistics with a value of 0.004 (pre-survey) and -0.236 (post-survey), which may have contributed to the total dependability being reduced. Excluding this item may enhance the overall reliability with a value of 0.918 (pre-survey) and 0.941 (post-survey) when using the "Cronbach's alpha if Item Deleted" approach.

Table 8. Reliability statistics (pre- and post-survey)

| | Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|---|
| Pre-Survey | 0.887 | 0.905 | 11 |
| Post-Survey | 0.884 | 0.908 | 11 |

Table 9. Item-total statistics (pre- and post-survey)

| | | **Scale Mean if Item Deleted** | **Scale Variance if Item Deleted** | **Corrected Item-Total correlation** | **Squared Multiple Correlation** | **Cronbach's Alpha if Item Deleted** |
|---|---|---|---|---|---|---|
| **Pre-survey** | Item 01 | 25.65 | 47.209 | 0.377 | 0.208 | 0.893 |
| | Item 02 | 26.36 | 44.736 | 0.815 | 0.792 | 0.868 |
| | Item 03 | 26.26 | 43.689 | 0.812 | 0.772 | 0.866 |
| | Item 04 | 26.25 | 43.951 | 0.822 | 0.751 | 0.866 |
| | Item 05 | 25.17 | 52.364 | 0.004 | 0.090 | 0.918 |
| | Item 06 | 26.29 | 44.530 | 0.723 | 0.633 | 0.871 |
| | Item 07 | 25.60 | 44.606 | 0.455 | 0.258 | 0.891 |
| | Item 08 | 26.30 | 43.386 | 0.825 | 0.790 | 0.865 |
| | Item 09 | 26.23 | 43.493 | 0.801 | 0.783 | 0.866 |
| | Item 10 | 26.01 | 42.447 | 0.782 | 0.711 | 0.866 |
| | Item 11 | 25.93 | 43.352 | 0.675 | 0.501 | 0.873 |
| **Post-survey** | Item 01 | 38.32 | 28.443 | 0.586 | 0.421 | 0.875 |
| | Item 02 | 38.51 | 27.599 | 0.776 | 0.672 | 0.865 |
| | Item 03 | 38.65 | 26.257 | 0.822 | 0.735 | 0.859 |
| | Item 04 | 38.61 | 26.725 | 0.827 | 0.747 | 0.860 |
| | Item 05 | 39.39 | 35.226 | -0.236 | 0.120 | 0.941 |
| | Item 06 | 38.63 | 26.999 | 0.828 | 0.742 | 0.861 |
| | Item 07 | 38.60 | 27.478 | 0.559 | 0.450 | 0.877 |
| | Item 08 | 38.81 | 26.476 | 0.801 | 0.745 | 0.861 |
| | Item 09 | 38.73 | 26.712 | 0.813 | 0.765 | 0.861 |
| | Item 10 | 38.59 | 27.090 | 0.752 | 0.659 | 0.865 |
| | Item 11 | 38.53 | 27.917 | 0.693 | 0.570 | 0.869 |

## Discussion

The aim of this study was to analyze whether or not integrating engineering-focused elements within a science methods course in the absence of teaching engineering to children would bring about changes in pre-service elementary educators' engineering teaching efficacy. In answering our first research question "How does participating in a K-8 engineering-focused course impact preservice elementary teachers' engineering teaching efficacy?", we found that participants experienced a significant increase in engineering efficacy after completing the course. This indicates that providing students with multiple opportunities to engage in engineering education within a single science methods course can boost PSTs' engineering teaching efficacy. Previous studies have mentioned that allowing educators to engage in design and engineering experiences over a long period of time could enhance efficacy (Bleicher & Lindgren, 2005; Hechter, 2011; Rich et al., 2017; Tosun, 2000). While the meaning of "long period of time" could be debated, the current study provides evidence that engineering teaching efficacy can improve when PSTs are provided multiple opportunities to engage in engineering related activities over the span of 15 weeks.

It is important to note that great gains were made in PSTs' engineering teaching efficacy in the absence of teaching engineering to children. One of the course activities required PSTs to watch multiple videos of elementary teachers delivering engineering instruction to children. After watching the videos, PSTs critically analyzed the teaching practices that they observed in the video. Having this opportunity to witness and critically reflect on elementary engineering instruction via classroom video footage could have helped demystify what engineering teaching looks like and enabled the PSTs to picture themselves in the shoes of the teacher on the video. While this is one possible explanation for the increases in teaching efficacy our participants displayed, further research is needed to identify the impact that each individual engineering component of the course had on the overall change in efficacy.

In answering our second research question, "Are there differences in preservice teachers' engineering self-efficacy between demographic groups?", we found that both female and male participants significantly increased their engineering teaching efficacy from pre- to post-survey, with female participants starting and ending with lower engineering teaching efficacy than male participants. However, while both groups significantly increased their efficacy from pre to post, female participants had a larger change in engineering teaching efficacy from pre- to post-survey than male participants. Higher engineering teacher efficacy scores for males than females have previously been reported (Hammack & Ivey, 2017); however, caution should be used when generalizing from these findings due to the low number of male participants.

Further, we found that there were no significant differences in efficacy gains between course modalities. This is a promising finding as it indicates that PSTs can enhance their engineering teaching efficacy through course work presented in face-to-face, blended, and online modalities. There has been an increase in the number of college students taking science methods coursework in online and blended modalities, highlighting the need for additional research in this area. In particular, research that looks more closely at the individual components of the course and the impacts each component has when implemented using different course modalities would help instructors make important course design decisions.

## Conclusion

The current study adds to the literature on engineering teaching efficacy in two important ways. Firstly, an important contribution of the current study is the reporting of reliability statistics for the Engineering Teaching Efficacy Beliefs subscale of the T-STEM instrument when used with elementary pre-service teachers. When the Friday Institute developed the original scale, they did not have enough participants to validate the engineering version of the T-STEM instrument. Thus, our work provides evidence to support the Engineering T-STEM to be a valid and reliable tool for measuring elementary pre-service teachers' engineering teaching efficacy.

Second, our work provides evidence that the inclusion of multiple engineering-focused components spread across a 15-week-long science methods course can enhance elementary preservice teachers' engineering teaching efficacy in the absence of practicing teaching engineering to children. It is crucial for pre-service educators, specifically those teaching at the elementary level, to have the chance to personally experience the EDP (Perkins Coppola, 2019). Generally, it has been found that allowing PSTs to have positive experiences with engineering design as a participant, and later as an educator during field experience, caused them to be more enthusiastic and also built their confidence (Perkins Coppola, 2019). Our study shows that varied experiences learning engineering design can result in increased efficacy, even in the absence of field experience and face-to-face coursework.

Given the large implications teacher efficacy has on not only the teaching of engineering in classrooms, but also how students learn, it is pertinent for preservice teachers to undergo training to understand engineering better, and to clear any misconceptions they may have about engineering teaching (Perkins Coppola, 2019). Moreover, self-efficacy plays a large and significant role in ensuring the best outcomes for student learning, and also affects how an educator runs their class. Thus, as seen in this study, the incorporation of a variety of engineering-focused activities within a single methods course can boost efficacy when it comes to elementary engineering education. With that being said, more studies will need to be carried out to better understand the effects of each course component and how the magnitude of impacts of each component varies with course modality. Future research pertaining to understanding these effects should also include qualitative approaches which could provide a more nuanced understanding of participants' experiences.

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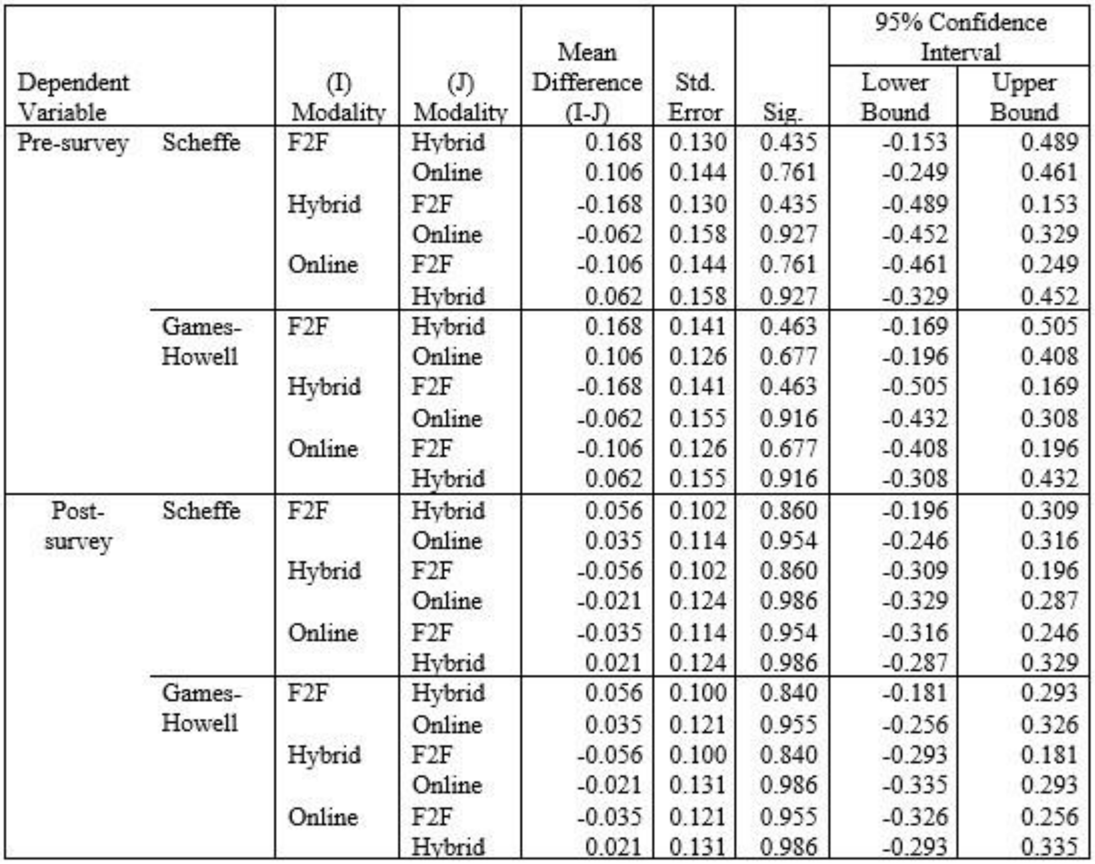
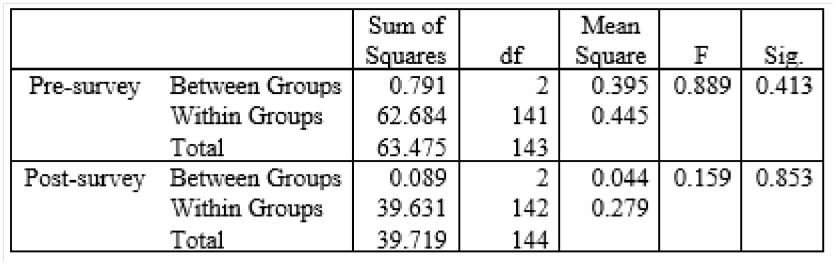
## Appendix A

Table 6. Multiple modality comparisons output (face-to-face, rapid shift online, hybrid)



| Dependent Variable | | (I) Modality | (J) Modality | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower Bound | Upper Bound |
| Pre-survey | Scheffe | F2F | Hybrid | 0.168 | 0.130 | 0.435 | -0.153 | 0.489 |
| | | | Online | 0.106 | 0.144 | 0.761 | -0.249 | 0.461 |
| | | Hybrid | F2F | -0.168 | 0.130 | 0.435 | -0.489 | 0.153 |
| | | | Online | -0.062 | 0.158 | 0.927 | -0.452 | 0.329 |
| | | Online | F2F | -0.106 | 0.144 | 0.761 | -0.461 | 0.249 |
| | | | Hybrid | 0.062 | 0.158 | 0.927 | -0.329 | 0.452 |
| | Games-Howell | F2F | Hybrid | 0.168 | 0.141 | 0.463 | -0.169 | 0.505 |
| | | | Online | 0.106 | 0.126 | 0.677 | -0.196 | 0.408 |
| | | Hybrid | F2F | -0.168 | 0.141 | 0.463 | -0.505 | 0.169 |
| | | | Online | -0.062 | 0.155 | 0.916 | -0.432 | 0.308 |
| | | Online | F2F | -0.106 | 0.126 | 0.677 | -0.408 | 0.196 |
| | | | Hybrid | 0.062 | 0.155 | 0.916 | -0.308 | 0.432 |
| Post-survey | Scheffe | F2F | Hybrid | 0.056 | 0.102 | 0.860 | -0.196 | 0.309 |
| | | | Online | 0.035 | 0.114 | 0.954 | -0.246 | 0.316 |
| | | Hybrid | F2F | -0.056 | 0.102 | 0.860 | -0.309 | 0.196 |
| | | | Online | -0.021 | 0.124 | 0.986 | -0.329 | 0.287 |
| | | Online | F2F | -0.035 | 0.114 | 0.954 | -0.316 | 0.246 |
| | | | Hybrid | 0.021 | 0.124 | 0.986 | -0.287 | 0.329 |
| | Games-Howell | F2F | Hybrid | 0.056 | 0.100 | 0.840 | -0.181 | 0.293 |
| | | | Online | 0.035 | 0.121 | 0.955 | -0.256 | 0.326 |
| | | Hybrid | F2F | -0.056 | 0.100 | 0.840 | -0.293 | 0.181 |
| | | | Online | -0.021 | 0.131 | 0.986 | -0.335 | 0.293 |
| | | Online | F2F | -0.035 | 0.121 | 0.955 | -0.326 | 0.256 |
| | | | Hybrid | 0.021 | 0.131 | 0.986 | -0.293 | 0.335 |

Table 7. ANOVA modality output (pre- and post survey)



| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Pre-survey | Between Groups | 0.791 | 2 | 0.395 | 0.889 | 0.413 |
| | Within Groups | 62.684 | 141 | 0.445 | | |
| | Total | 63.475 | 143 | | | |
| Post-survey | Between Groups | 0.089 | 2 | 0.044 | 0.159 | 0.853 |
| | Within Groups | 39.631 | 142 | 0.279 | | |
| | Total | 39.719 | 144 | | | |