Enhancing Interest in Cybersecurity Careers: A Peer Mentoring Perspective

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ABSTRACT

The focus of this paper is an evaluation of our peer mentoring framework designed to encourage more students to seek cybersecurity career pathways through providing peer interactions. We present and compare results from two years (Spring 2016 and 2017) of interaction between students in an introductory Information Systems class *(IS 300: Management of Information Systems)* and an upper-level elective Cybersecurity course *(IS 471: Data Analytics for Cybersecurity)*. Our results show a continuation of the general trend observed in the 2016 study. The students who receive peer mentoring show more interest in cybersecurity issues and careers and gain more overall knowledge throughout the semester, than those who don't. This is reflected by the results of an anonymous survey and overall grade improvements. These students show more variations regarding their choice of cybersecurity as a career compared to students who did not receive any mentoring, demonstrating that they are able to make more informed decisions. Female students exhibit more pronounced responses to peer mentoring in contrast to their male counterparts.

KEYWORDS

Cybersecurity; Workforce Development; Peer Mentoring; Information Systems

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1 INTRODUCTION

Cybersecurity career pathways and roles are an ever increasing need of the workforce as the world becomes more connected and more emerging threats are identified in multiple and newfangled areas of our lives ranging from traditional networks, mobile devices to Internet of Things [22]. Workforce development in this area is inadequate as cybersecurity certificates and programs are few and limited in their scope. Moreover, there is a lack of awareness of the myriad of career options in the cybersecurity field. Our work is motivated to fill this gap. Academic programs are uniquely placed to address this need by encouraging students with a deeper understanding of the cybersecurity career spectrum. We have created a unique undergraduate certificate program in the Information Systems Department that targets the student curriculum at the intersection of Data analytics and cybersecurity. In addition to the new curriculum, we have also instituted a peer mentoring program where students in an introductory technology course are able to interact with students in the upper level cybersecurity elective class.

Peer mentoring refers to the matching of more experienced students with less experienced students who are typically in the early stages of their programs. Peer mentoring has been well accepted and known to be effective [1–11, 13–20, 23–28] in inculcating (a) better academic performance after the first year and reduction of student attrition over all four years in the student mentees and (b) an increase in critical thinking, leadership skills, and abilities for the student mentor. Our framework is based on the evidence from these prior studies indicating that peer mentoring works well in a structured curriculum and shows increased retention with students in the experimental groups earning higher grades and developing critical thinking skills. In this paper we outline the structure of the peer mentoring exercise for undergraduate students, established between the advanced cybersecurity course, *IS 471: Data Analytics for Cybersecurity*, with *IS 300: Management of Information Systems*, a gateway course and the first IS-specific course that IS majors take. Courses before IS 300 build specific foundational skills in programming, economics, and math. This is also the place where students are beginning to explore career pathways. Moreover, this gateway course offers an opportunity to increase participation in advanced technology courses as the gender and under represented groups are still at a slightly higher percentage than in some of our advanced electives. On an average UMBC has about 46% female and 22% underrepresented groups, while the IS department as a whole has roughly 19% female and 22% underrepresented groups. In some of our upper level electives such as Data Mining (2017 Fall) we have 23% female and 33% underrepresented minorities. In IS 300 we have seen over 27% females and 27% minorities (2017 Spring). Thus, we hope to encourage some of these students into advanced technology careers through peer mentoring and increase participation in this important area of STEM education and cybersecurity careers.

In this paper our aim is threefold,

- We evaluate the peer mentoring model and compare findings across two semesters of this study to evaluate whether we have been able to encourage students to pursue cybersecurity careers. We also investigate if, beyond the peer mentoring

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exercise, more and more students (particularly with diversity) are enrolling in the advanced cybersecurity electives across the two years.

- We evaluate the impact of cybersecurity exercises as part of regular lectures (in a Control section of IS 300) as compared to peer mentoring (Experimental section of IS 300) to see if the impact is significant especially for the underrepresented groups.
- We also discuss qualitative results by evaluating student assignments in the IS 300 courses to see the depth of knowledge gained by the experimental vs the control group. Both these courses are offered by the same instructor who provided additional qualitative insights.

The rest of the paper is organized as follows: we begin with a brief outline of the intervention study design. In section 3 we evaluate, compare and analyze the trend from the two year data. Finally, we discuss the future directions of the project in section 4.

2 METHODOLOGY

The methodology of the peer mentoring approach is based on earlier work [12], discussing peer mentoring results from a one semester offering of this intervention. Figure 1 summarizes the study methodology across the two sections (experiment IS 300E and control IS 300C) of IS 300 and the interactions with peers from IS 471.

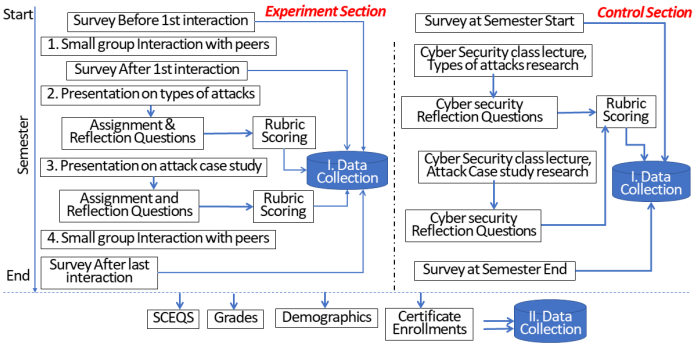

Figure 1: Study Design: Experiment Vs. Control

2.1 Peer Mentoring Approach

Once every month, students in IS 300E interacted with the IS 471 students in a classroom setting through small-group conversations and presentations from the advanced class of students. The two courses were scheduled in the same time slots to facilitate coordination. Both IS 300C&E were taught by the same instructor. IS 471 students provided advanced insights, knowledge, and skills to IS 300E students to enhance relevant assignments in cybersecurity. As peer-mentors the IS 471 students also provided information and insights into cybersecurity careers to potentially raise the IS 300 students' awareness of and interest in course work and career paths in cybersecurity. IS 300 students wrote short reflection statements, discussing insights gained and lessons learned through the cybersecurity presentations as well as their interactions with IS 471 students as part of two assignments. IS 471 students responded to reflection questions and surveys to reflect on the benefits they gained through these interactions. The interactions between IS 300E and IS 471 included two short interactions (at the beginning and end of the semester) where small groups (with a mix of IS300E and IS471 students) interacted with each other through unstructured discussions, guided by some leading questions regarding cybersecurity careers. Throughout the semester IS 300E students attended presentations on types of attacks and attack case studies done by the IS 471 students. These were quick, short presentations that were highly animated and interactive with lots of Q&A. Following these presentations students completed short essay type questions on these topics by selecting a type of attack and a case study to research for their assignment. In IS 300C these presentations from peers were replaced by classroom lectures and research done by the students individually.

There were two surveys conducted before and after the interventions in the IS 300E and 471 classes. There were also two surveys conducted in the control section of IS 300 to evaluate the efficacy of classroom instruction about cybersecurity and self-guided assignments. The pre-survey done before the first interaction in IS 300 included questions such as: *"Do you know what cybersecurity is?"*, *"Are you interested in learning more about cybersecurity?"*, *"Do you know of careers in cybersecurity?"*, *"How likely is it that you will pursue a career in cybersecurity?"*

The post-survey after the fourth intervention repeated these questions and included additional questions on how they evaluated their interactions with IS 471 students. Some of the survey questions for IS 471 included: *"How helpful to you was having a conversation with the IS 300 students, particularly in thinking through reasons for your interest in cybersecurity as an area of study?"*, *"Did this interaction help you gain confidence in talking about your understanding of cybersecurity?"*

2.2 Differences across 2016 and 2017

We wanted to introduce redundancy to better understand the interactions between students and reasons for their answers through their responses to additional position statements over time. Therefore, we asked students to choose one of five position statements in all of the surveys (before and after) for both IS 300 groups and IS 471: *"Learning Cybersecurity is interesting"*, *"Cybersecurity topics do not change over time"*, *"I think cybersecurity is hard"*, *"I believe I can master Cybersecurity knowledge and skills"*, *"Understanding Cybersecurity will help solve important problems such as data leaks, national security etc."*. All of these questions had five possible responses: *Strongly agree, Agree, Neither agree or disagree, Disagree, Strongly disagree*. These additional questions proved much more valuable during our analysis when we found a few contradictory results (discussed in section 3).

We next discuss results obtained by evaluating the surveys.

3 RESULTS

The results compare the data collected through the surveys to evaluate (a) perceptions before and after the interactions, (b) results across the control and experiment sections and (c) results across two years.

The gender and ethnicity distribution of the sections across the years 2016 and 2017 are detailed in table 1 and 2 respectively. The total number of students in each group is denoted by **'N'** in the table headers. The percentage of female students almost doubled from 2016 to 2017. Anecdotally we also saw some students from

Gender	Spring 2017			Spring 2016		
	IS300E (N=39)	IS300C (N=40)	IS471 (N=22)	IS300E (N=38)	IS300C (N=33)	IS471 (N=22)
Male	59%	75%	67%	82%	91%	82%
Female	38%	20%	33%	15%	6%	18%
Unspecified	3%	5%	0%	3%	3%	0%

Table 1: Gender Distribution (in percentage)

Ethnicity	Spring 2017			Spring 2016		
	IS300E (N=39)	IS300C (N=40)	IS471 (N=22)	IS300E (N=38)	IS300C (N=33)	IS471 (N=22)
Unspecified	8%	5%	6%	3%	24%	13%
White	28%	35%	32%	42%	18%	31%
African-American	15%	17%	16%	16%	15%	15%
Asian	46%	32%	39%	26%	33%	30%
Multiple races	0%	5%	3%	13%	6%	10%
Other	3%	5%	4%	0%	3%	1%

Table 2: Ethnicity Distribution (in percentage)

the peer mentoring interactions in 2016 enrolling for IS 471. So in general these exercises are generating more interest across the department as a majority of the students are passing through either of the IS 300C or IS 300E courses. This is indeed an encouraging finding.

3.1 Comparison across 2016 and 2017 in IS 300E and IS 471

In 2016 we observed that a majority of the students in IS 300E and IS 471 found these interactions helpful. That trend continues to improve in 2017. In 2016 the percentage of students in IS 300 who found these interactions *very* or *moderately helpful* were 82%, in 2017 we found 92% of the students responding with similar positivity to these questions (figure 2).

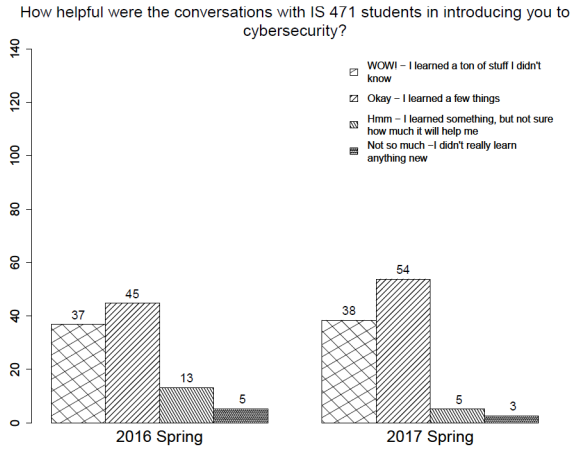

Figure 2: Helpfulness of conversations: IS 300E

Figure 3 shows IS 471 students' response to the question regarding the *helpfulness* of the interactions. Compared to 2016, in 2017 the IS 471 students found these interactions much more helpful. After final interaction, in 2016 54% found these interactions to be between *moderately* to *extremely helpful*, 2017 saw that percentage rise to a complete 100% and there were no students who had any negative response to these interactions. Another interesting observation is that during the 2016 study, the IS 471 students found these interactions a little *less helpful* (14%) towards the end of the semester, whereas in 2017 the IS 471 students felt that these interactions are getting much *more helpful* (25%) as they approach the end of the semester. This indicates the level of confidence gained by the IS 471 students in talking about cybersecurity, which was also observed by the faculty teaching IS 471 through classroom discussions about the peer mentoring exercises. This is possibly also a result of managing the interactions better across the years. There is some level of noise in these descriptive statistics, given the size of the dataset. In our future work we plan to perform statistical tests of significance across three years of this study to conclude with significant findings.

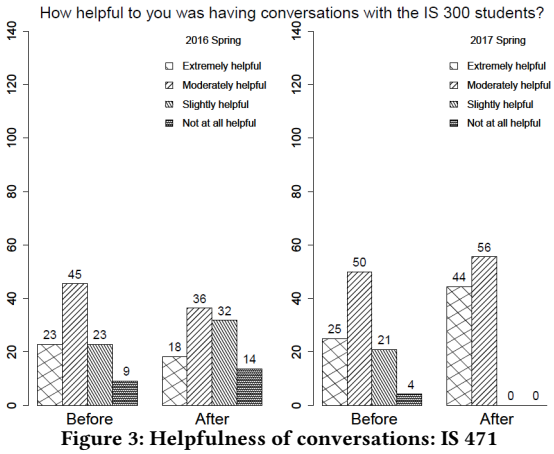

Figure 3: Helpfulness of conversations: IS 471

In 2016, more than two thirds (68%) of the students in IS 300 reported an increased interest in cybersecurity as a result of the interactions. 2017 saw the number raise to 79% (net 11% increase) with zero reporting on any decreased interests (Figure 4)

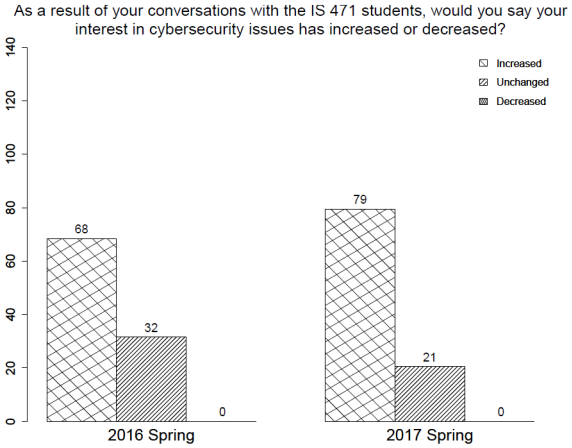

Figure 4: Increased Interest in Cybersecurity: IS 300E

2016 saw a general improvement in response to the question about likelihood of IS 300 students pursuing cybersecurity careers both in the control and experiment section. IS 300 students who had interactions with IS 471 students were around 4% more likely to pursue cybersecurity careers than the students who did not have the interactions by the end of the semester. The results are slightly

different in 2017; while the difference for *highly likely* is the same (12% more), it appears that students from the experiment group are at least 8% *less likely* to choose a career in cybersecurity (Figure 5). However, we do see some interesting findings in gender based comparisons discussed later.

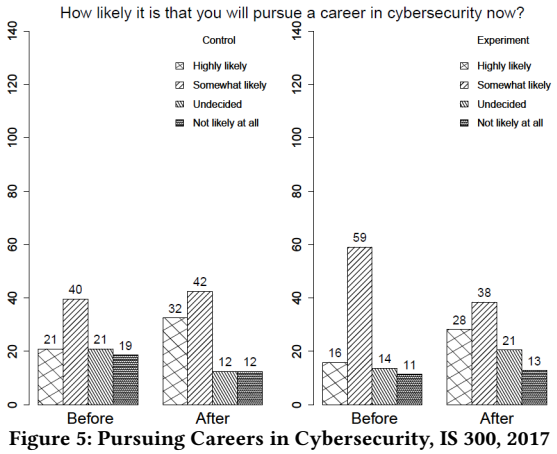

Figure 5: Pursuing Careers in Cybersecurity, IS 300, 2017

A possible explanation for this result could be that as the students in the experiment section have access to IS 471 students' interaction and case study presentations sessions and are able to better judge the depth of their knowledge, interests and career options, they can become more opinionated compared to the students from the control section. This hypothesis can be tested by analyzing the position statements from 2017. The summary of the results are shown in table 3 (due to space constraint, we are only showing the significant differences). The experiment section does not find cybersecurity as interesting as the control section and they find cybersecurity a bit harder than their control counterparts, but at the same time more of them think they can master cybersecurity knowledge and skills and more of them think that cybersecurity is important for national security. These observations show that the experiment section makes more informed decisions later on as they have more interactions. They become more confident about their abilities with cybersecurity topics but this does not necessarily translate to their responses to choosing cybersecurity careers in general. This needs to be further evaluated in the third year of our study as these position statements have only been introduced in 2017 so there is no comparison across 2016. It is also possible that these interests will be evident later on in their careers as we saw in the case of some students going through the peer mentoring exercise in 2016, who enrolled in the IS 471 class in 2017.

3.2 Gender Specific Differences in Responses

In both years of the study, we have observed an encouraging and consistent trend that female students exhibit more positive responses to the questions compared to their male counterparts. The female students generally find these interactions more helpful and interesting and their self-assessment of knowledge gain is also higher than the male students. When asked about choosing cybersecurity as a career their responses are still not as positive as their male counterparts, but they show increased interest (for example from not interested to undecided) and variations in their responses

	Control	Experiment	Observation
Learning Cybersecurity is interesting	26% increase in strongly agree (rest decreasing)	11% increase in agree (rest decreasing)	Control section shows stronger agreement to the statement
Cybersecurity topics do not change over time	18% increase in strongly disagree (rest decreasing)	5% increase in agree & 10% increase in disagree (rest decreasing)	Control section shows stronger disagreement to the statement
I think cybersecurity is hard	6% combined increase in disagreement (rest decreasing)	6% decrease in undecided, almost even increase in agree & disagree percentage	Control section shows more disagreement to the statement
I believe I can master Cybersecurity knowledge & skills	4.1% increase in undecided (rest decreasing)	4% increase in strongly agree & 11% increase in undecided (rest decreasing)	Experiment section shows more agreement to the statement
Understanding cybersecurity will help solve important problems such as data leaks, national security	9% increase in strongly agree & 2% increase in strongly disagree (rest decreasing)	13% increase in strongly agree, 3% increase in neither & 5% increase in strongly disagree (rest decreasing)	Experiment section shows more agreement to the statement

Table 3: IS 300 Spring 2017 Position Statement Results

as compared to the male students. For example, in 2016 all of the female students (100%) in the experiment section found the interaction with IS 471 students *extremely helpful* compared to a 77% male positive response (Figure 6). The next year (2017), we also saw a 100% response in the helpful side compared to a 87% male positive response. (Figure 7)

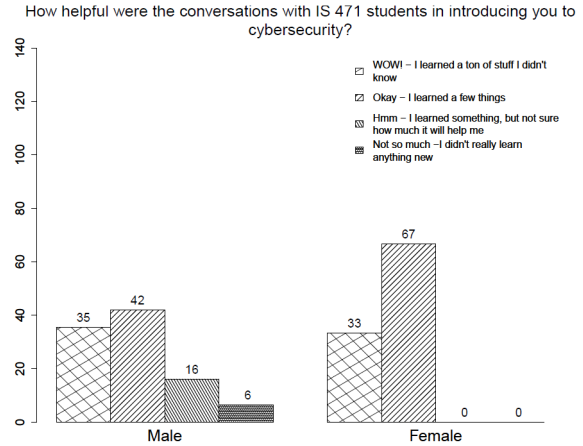

Figure 6: Helpfulness of Interactions 2016, IS 300E Females Vs. Males

Female students in the experiment section also show equal or higher increased interest in cybersecurity issues as a result of their conversation with IS 471 students as compared to the male students of the same section. When comparing the responses to their female counterparts from the control section, we also observed the evidence of positive effect of peer mentoring. In response to the question *"Do you know what is cybersecurity"*, the female students from the experiment section show 60% knowledge gain compared to 29% knowledge gain by the male students (in 2017, figure 8). Without the peer mentoring intervention, the knowledge gain increases are 23% and 37% for female and male students respectively

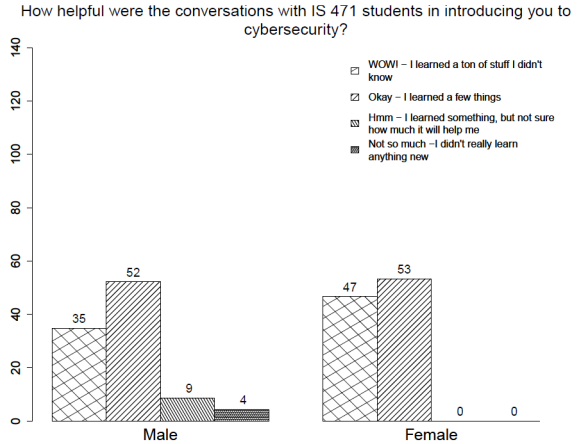

Figure 7: Helpfulness of Interactions 2017, IS 300E Females Vs. Males

(figure 9). The increased knowledge gains appear to greatly influence the responses regarding the interests in cybersecurity learning and career choice for female students. The responses to the question *"Are you interested in learning more about cybersecurity?"* is much more varied in the female students in the experiment section compared to males in contrast to the same comparison on control section (Figure 10 and 11).

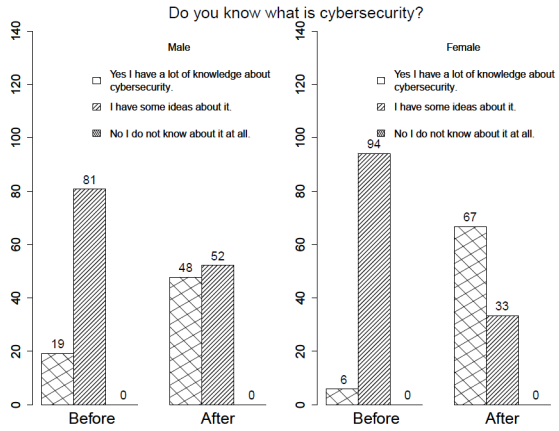

Figure 8: 2017, IS300E: Do you know what is cybersecurity?

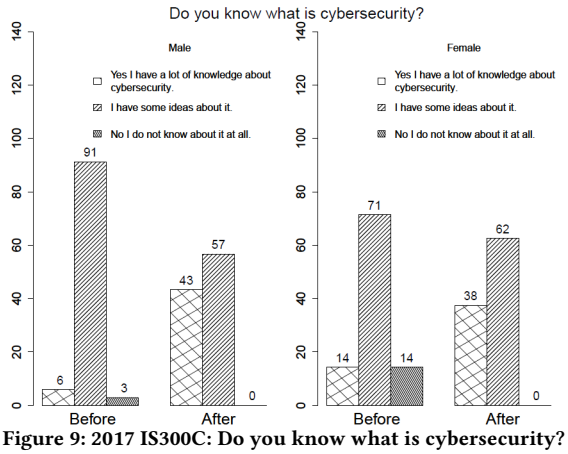

Figure 9: 2017 IS300C: Do you know what is cybersecurity?

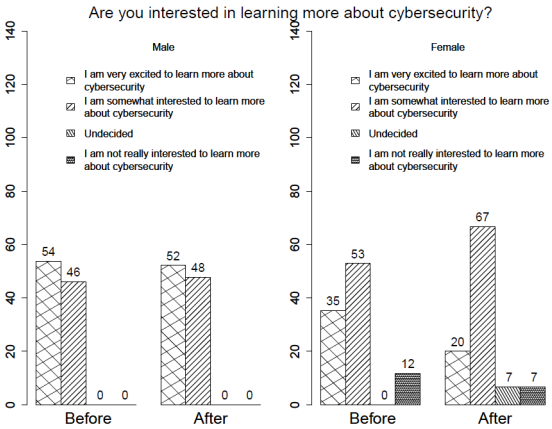

Figure 10: 2017 IS300E: Interest in learning more

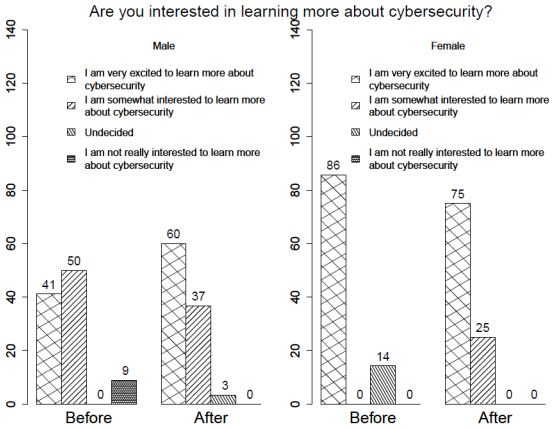

Figure 11: 2017 IS300C: Interest in learning more

These show that female students are much more receptive to the peer mentoring interventions and they are more likely to make more rigorous informed decisions on further cybersecurity study and careers compared to their male counterparts.

3.3 Grade Analysis of the Cybersecurity Assignment

IS 300 students from both control and experiment sections were given two assignments on cybersecurity throughout the semester. The first assignment was on *types of cyber attacks*, where the students were asked to write an essay on a specific type of cyber attack from a predefined list. They were asked to provide a description of the attack, example incidents, commonly affected businesses and preventive measures against the attack. The second assignment was a *cyber attack case study* where the students were asked to write an essay on a recent cyber attack incident. They were asked to provide the background, estimated damage, targeted audience, resolution and lessons learned from this case study. The difference between the experiment and control section was that the IS 300E students attended presentations made by IS 471 students on multiple *types of cyber attacks* and *case studies* prior to these two assignments. The assignments were graded by the same instructor who taught both the control and the experiment section during that same semester.

On the first *types of cyber-attack* assignment, the IS 300 students from the control section have slightly higher class average

and lower standard deviation than the experiment section, but at the later part of the semester when they are given the *case study* assignment, they fall behind compared to the students from the experiment section. For the *types of attack* assignment, the control section students may be able to find adequate information over the traditional Internet resources, but the *attack case study* assignment is much more complex in nature; the IS 300E students are possibly able to gain more knowledge here, as they attend the presentations and accompanying Q/A sessions from the IS 471 students. They are able to better understand these complex issues in contrast to the students from the control section who can only use self guided research as the primary resource. This pattern is observable in both 2016 and 2017, experiment section's average score increases in the second assignment and variance goes down, the control section exhibits the the opposite trend in both years.

4 CONCLUSION & FUTURE WORKS

In this paper we outlined results of two years of a peer mentoring study. An earlier study was introduced in [12]. The compilation of two years of data helped to validate the results from the 2016 study; that the students receiving peer mentoring gain more overall knowledge about cybersecurity issues and careers and are able to make more informed decisions about their career choices. Having more overall positive responses from female students under peer mentoring is also a very promising result, given the general lower percentage of females in cybersecurity and in general STEM careers [21]. The works presented here are just a small portion of the full analysis being done on the two years of data collected. We did not discuss the text analysis comparisons (readability, expressiveness and sentiment analysis) of the essays written by the students of both the experiment and control groups. In the upcoming spring 2018, we plan to use improved questionnaires to better understand the difference in the self-reported change in interest vs the derived change in interest in cybersecurity of the IS 300 students. We also plan to investigate a measure of knowledge gain between the groups to avoid potential false positives and incorporate robust statistical analysis. The increased interest in cybersecurity could be further examined to determine if the interest resulted in an increase in enrollment or majors. It would also be interesting to conduct exit surveys over years to find how many students actually sought and got cybersecurity jobs.

5 ACKNOWLEDGMENTS

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