

# Factors Impacting Cybersecurity Students' Classroom Success with Their Worries Towards Success

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**Abstract** – A variety of factors that are impacting how well cybersecurity students do in the classroom as well as their worry levels are analyzed qualitatively and quantitatively in this Institutional Review Board (IRB) approved study. The data is collected from 103 students at a university located in the Northeastern side of the United States with the quantitative data analysis applications including statistics, data distribution with model fitting, correlation with heatmap evaluation, cross-correlation, and Mann-Whitney U-test while qualitative analysis is based on video recorded and transcribed undergraduate cybersecurity students' responses as a follow-up to their answers to the research questions; The qualitative data collected targeted to furthermore understand the participants' written responses with explanations. Participants are compensated with money for taking place in the video recorded interviews. Combined qualitative and quantitative analysis indicated highest cross correlation between the worry levels of how students do well in the classroom and their desire to have a good job; this may be due to participants' higher desire to have a good job resulting in higher stress levels and worries on doing well in the classroom. Looking at the qualitative analysis of the data, the correlation between participants who want to solve challenging cybersecurity students appear to believe that they need to do well in the classroom to be well prepared for solving challenging real-world cybersecurity problems.

**Index Terms** - Cybersecurity undergraduate student education; Cybersecurity students' worry levels towards success; Factors impacting cybersecurity students' success; Pedagogical cybersecurity research.

## INTRODUCTION

The field of Cybersecurity is proving to be one of the important fields that have many implications that include but not limited to finance, health care, and manufacturing. Due to the importance of this field, it is important to study the best ways to educate professionals and researchers for their successful work in these roles for the future of systems' cyber threat handling. On the contrary to the importance of the field, there has not been much attention paid to the

pedagogical aspect of understanding the best strategies of cybersecurity students' learning. One of our aims in this work is to study factors impacting cybersecurity students' classroom success that impact their worries towards success by collecting empirical data from cybersecurity undergraduate students.

Successful performance in academia is very important to the success of the future professionals that would impact the future of cybersecurity workforce and researchers. Therefore, understanding the factors that make up the individual's success is very important for closing the associated gaps by possibly engineering cybersecurity education after understanding such gaps from a pedagogical perspective. One such area of interest that we focus on is related to the factors that would limit students' success in the classroom the most. The associated research literature is very limited with no trace of any research conducted similar to this work; examples of somehow relevant studies include focusing on how socio-psychological factors such as age, gender, and educational level affect students' cybersecurity learning at Malaysian universities [1], the benefits of an out-of-class learning approach in helping students to fulfill cybersecurity educational outcomes and how they may enhance the perceived value of cybersecurity education [2], an examination of a knowledge-attitude-behavior model and its influence on internet security awareness of people [3], an observation of a significant shortfall in the number of cybersecurity experts with the skills required in professional settings with a pressing need for cybersecurity professionals [4], and a study on the identification of both risk factors and protective factors associated with cybersecurity risk judgment on K-12 students and teachers [5]. Although, these studies do not address a gap in the way we present our research results on the pedagogical matters, they touch upon strategies for learning the associated concepts, and the psychological factors that impact the learning of students in a STEM-based field, primarily in the cybersecurity field. Therefore, to the best of our knowledge, this work addresses factors that differ from any other research results attained in the literature by studying the factors that influence a student's performance towards success in the cybersecurity field. Factors that are listed as such include; being a member of a minority group, the desire to make more money in the directed field, being the first-generation college graduate

from the family, the aim to gain a better career prospect, the ambition to tackle challenging problems within the field, encouragement of professors' to continue the completion of the college degree, and finally, just an interest in learning the concepts and theories within the field.

In the next section, we briefly outline the research methodology followed for collecting and analyzing the data. The following section focuses on the quantitative results that outline the statistical results collected from the participants based on their answers to the research questions. What follows is the qualitative analysis of the data gathered from the research participants via the video interviews conducted by the Principal Investigator (PI) and the analysis of the associated data. Finally, the conclusions and future work are summarized in the last section to outline a comprehensive summary of the study and the attained results.

### RESEARCH METHODOLOGY

The data for this research study was gathered in a public 4-year university in the Northeastern side of the United States. The study was governed by a Principal Investigator (P.I.) and a team of five research assistants during the study's research span of five months. Prior approval of IRB is attained to make sure that the proper research guidelines are followed. Throughout the gathering of the data for this study, the consent of each participant is attained at the two stages of the research; one for the survey and another one for the video recorded interviews. The primary data collected from the survey was the principal tool used for the data collection of the students for the quantitative results. The data is collected only from students majoring in the cybersecurity field and thus the survey was tailored to those students' specific experiences in mind. The survey was completed by 103 students and was designed to address two aspects of interest:

- The factors that impact how well cybersecurity students do well in the classroom.
- Factors that impact cybersecurity students' worries in the classroom.

The quantitative analysis of the students' responses is based on the statistical analysis to be outlined in the next section. The qualitative data is gathered as a result of video interviews of the participants that ranged between 30 to 40 minutes. The interviews were conducted by the PI with probing questions to extract more specific information about the reasoning behind pre-interview responses of the participants. All the video interviews are recorded and transcribed for the qualitative analysis and compared with quantitative results. Participants are compensated with money for taking place in the video recorded interviews. The statistical calculations from the survey questions' answers create the basis for the quantitative results while the video interviews created the basis for the qualitative results.

### QUANTITATIVE RESULTS

The quantitative analysis results presented in this section are derived from the numerical data collected from the participants based on their responses to the questionnaire provided to them. This quantitative analysis served as the initial analysis of the factors that impact how well participants do in the classroom with the associated distribution of the collected data. The techniques used included the following:

- Statistical data distribution equation
- Mann-Whitney test
- Kruskal-Wallis Test
- Correlation analysis
- ANOVA with heatmap

These quantitative results will be interpreted in this section, and the results will be combined to the qualitative results later in this work to provide stronger conclusive results.

#### *I. Statistical Data Distribution & Correlations*

Factors that impact cybersecurity students' work and how well they do in the classroom can be multifold and this section aims to focus on a set of factors to be analyzed driven by the collected data. The distributions that fit to the data indicate the data trends based on the differences between the choices made by the participants. There are two questions with two parts that we focus on this research with the analysis focusing on two different factors: Doing well and worrying about doing well in the cybersecurity classes taken.

**Part A.** The factors that impact how well cybersecurity students do well in the classroom

- Being a member of minority and it impact on the learner
- Making a lot of money
- Being the first generation in the family of the learner that attends a college to complete a degree
- Desire to have a good job with good pay one day
- Excitement to solve some of the cybersecurity problems in real-life
- Some of the professors motivating the learner to continue my degree
- The course concepts motivating the learner a lot

**Part B.** Cybersecurity students worrying about how well they do in the classroom with the associated factors.

The major contribution of Part A is to understand the factors that motivate cybersecurity students to be in the major and motivate them to continue their success in the classroom. These motivational factors are important to understand as they are the main psychological drivers of the students to continue their wellness in educational success. On the contrary, Part B focuses on whether they worry or not about doing well in the classroom. Figure 1 below highlights the statistical distribution of the participants

choices to Part A of the research with a cubic model fitting as indicated by the  $R^2$  value of 96.33%. Among the list of the choices of the participants, wanting a good job is determined to be the top choice by the participants with a percentage of 26.29%. Solving challenging problems placed second with 21.65% of the participants' interest. Making money and course concepts are determined to motivate students at the same level with a percentage distribution of 12.89%. A percentage value of 12.37% is attained for the option of being the first generation in the family that attended a college. The lowest percentage was determined for being a member of minority with 4.12% of the participants selecting this option.

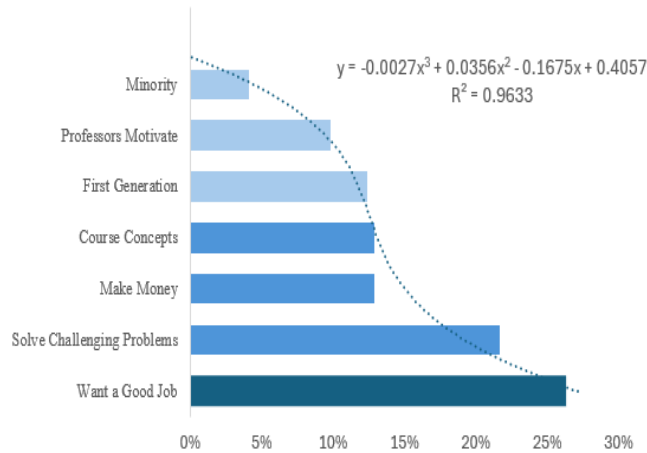


FIGURE I

PART A'S DATA DISTRIBUTION OF PARTICIPANT CHOICES

Figure 2 is a heatmap of the correlation values between coupled variables that are organized according to the column variable selections. This heat map is asymmetric in nature due to the relative correlation of the variables. For instance, in this figure, those who selected minority as an option that also selected making money had 50% correlation with respect to the number of minority selections in the corresponding column while the intersecting column values between making money and minority is 32% based on the number of those who selected to make money.

	Minority	Make Money	First Generation	Want a Good Job	Solve Challenging Problems	Professors Motivate	Course Concepts
Minority		32%	29%	14%	14%	10.53%	12.00%
Make Money	50%		95.83%	45.10%	38.10%	47.37%	44.00%
First Generation	87.50%	92.00%		39%	40.48%	42.11%	40.00%
Want a Good Job	87.50%	92.00%	83.33%		80.95%	73.68%	88%
Solve Challenging Problems	75.00%	64.00%	71%	66.67%		78.95%	84.00%
Professors Motivate	25.00%	36.00%	33.33%	27.45%	35.71%		44.00%
Course Concepts	37.50%	44.00%	41.67%	43.14%	50%	57.89%	

FIGURE II

HEAT MAP OF PART A'S COUPLED DATA CORRELATIONS

The heatmap structure of the data indicates a good number of the participants who want to have a good job and solve challenging problems also picking other options of Part A due to relatively high correlations with other groups. The lowest percentage of these correlations occurred for the selection of minority and professors' motivation that indicates the participants who chose these options did not show high interest in the selection of the other options. Figure III below shows the average and standard deviation values of the correlations displayed in Figure I.

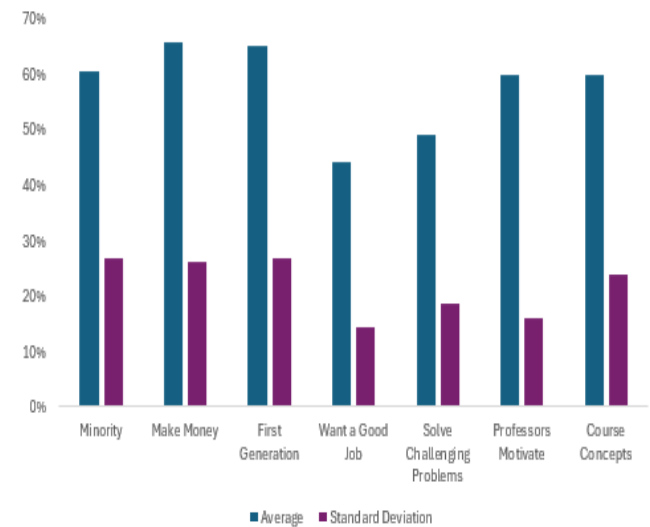


FIGURE III

AVERAGE AND STANDARD DEVIATIONS OF PART A'S DATA CORRELATIONS

Table I below numerically outlines the nature of Figure III data. This table demonstrates an overview of the averages and standard deviations of the coupled data variable correlations; The typical average of the correlations is ranging from 60 to 66% range for five of the seven options indicating most of the participants choices correlate for these five variables. The highest correlation average value of 65.6% is attained within the group of making money meaning the highest correlation average of choices occurred with other options in this group. The lowest average of 44.31% and the corresponding standard deviation of 14.25% are attained for those who wanted to make money.

TABLE I

A SUMMARY OF AVERAGE & STANDARD DEVIATIONS OF CHOICES

Option	(Average, Standard Deviation) in %
1 Minority	(60.42, 26.71)
2 Make Money	(65.6, 26.17)
3 First Generation	(65, 26.78)
4 Want a Good Job	(44.31, 14.25)
5 Solve Challenging Problems	(49.05, 18.64)
6 Problems Professors Motivate	(60, 16.05)
7 Course Concepts	(60, 23.83)

Part B of the research focused on the levels of worry as a counter factor to the part A responses as such factors can demotivate students to do worse depending on the levels of worries. Figure IV below demonstrates a brief overview of the results with an indication that about two thirds (i.e. 67%) of the participants are worried about how they do in the classroom while 27% mentioned it to be sometimes and 6% of the participants are not worried about it at all.

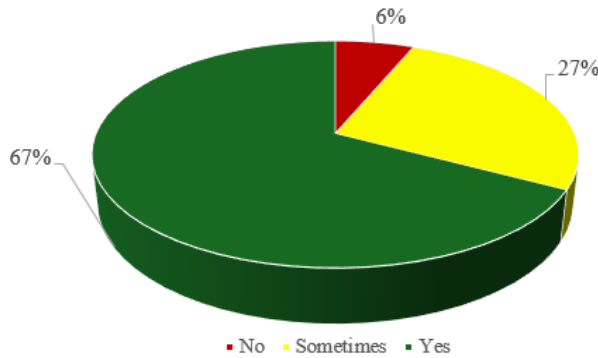


FIGURE IV

WORRY LEVELS OF HOW WELL CYBERSECURITY STUDENTS DO IN THE CLASSROOM

Overall, the numerical results indicated the primary motivational factor for success in the classroom to be the desire to have a good job with the secondary option to be the desire to solve challenging problems in the cybersecurity field. The least motivational factor is identified to be a member of a minority group.

## II. Cross Correlation Analysis of Motivational Factors & Worry Levels

In this section we take a close look at the cross correlation between Parts A and B results to evaluate the correlation impact of one on the other. Figure V below to be explained next outlines the distribution of each one of the major selections for Part A in correlation to the Worry levels stated in Part B.

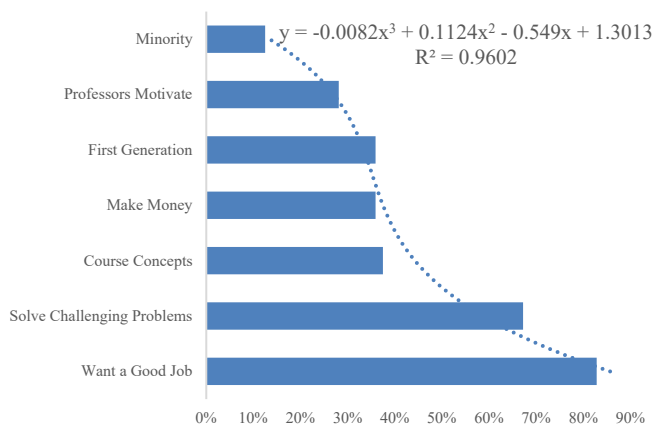


FIGURE V

CROSS CORRELATION OF WORRY LEVELS AND DOING WELL

This figure, just like Figure I, has a strong cubic distribution fit with a very similar structural design; It has an  $R^2$  value of 96.02% with the top choice being the desire to have a good job and the secondary choice being the desire to solve challenging problems. This graph indicates that these two groups have the highest correlation of the worry levels of how they do in the classroom with their primary choices. Given the low percentage of “no-worry” levels of the participants, this figure is a clear indication that these two groups have the highest worry levels.

## III. Mann-Whitney U Test on Participant Selections

The evaluation of the participants’ selections of Parts A and B is necessary to identify if the ranking matters when it comes to the cross-correlation evaluation. For such a reason we employ the Mann-Whitney U Test to identify the significance levels of the categorized data. The categorized group data consisted of the choices made for Part A to be group 1 while the choices made for Part 2 to be group 2. The non-normal nature of the data distributions for both parts makes this test applicable for advanced analysis. Group 1 had Part A results formed by the seven categories while group 2 consisted of the three options used for Part B responses. Initially, non-parametric statistical Mann-Whitney U test application indicated to accept the null hypothesis at a level of  $\alpha=0.01$  confidence level, therefore the selections of the participants between the two groups identified for Parts A and B do not have significant differences from each other.

## QUALITATIVE ANALYSIS AND RESULTS

Qualitative results have a tremendous place in understanding the quantitative results shown in the prior sections. The qualitative results that we present in this section are results of video recorded follow-up interviews of the research participants who are cybersecurity undergraduate students. Each participant is compensated for taking place in a 30–40-minute video recorded interview by the Principal Investigator (PI), and the conducted video recording interviews are transcribed for furthermore analysis of the results attained. Integrated qualitative and quantitative responses will be presented in the last section of the article. We will demonstrate several examples of the collected qualitative data in this section for both Parts A and B.

As educators and researchers, we need to know and understand the factors that impact cybersecurity undergraduate students’ learning in the classroom and their worry levels. On one side the factors that motivate students to be in the major of their selection and the courses they pick positively reinforce their learning while factors such as worries, anxiety, economics etc. negatively impact their motivation and learning in the classroom therefore the PI followed up on the questions that relate to the factors that impact how cybersecurity students do in the classroom as well as their worry levels. Each person reflected on personal real-life and educational experiences with examples given. For instance, the following Research Participant (RP) is a

member of the minority and has worries about doing well in the classroom.

**Interviewer.** Do you believe there are factors that impact how well you do in the classroom and if you choose the ones that apply in this list?

**RP 1...** I'll put yes to a member of minority. Yes, I wanna make a lot of money. Yeah, I will say yes to the first generation, the family to complete college. Yes, I want a good job with good pay one day. Yes, I'm excited to solve cybersecurity problems. Yeah, I would say professors motivate me to continue my degree. And yes, the course concepts motivate me a lot. ...Initially I was looking more for the just to get the undergraduate degree, but I'm definitely considering with these factors going for the graduate degree.... for making money I feel like, at least in this field, I don't know if you necessarily also need a master's or PhD to get a high paying job necessarily. So that can kind of in some ways negatively impact me because I feel like I'd rather finish school and just start making good money right away, but it is impacting me like some of the other choices. I mean they're all impacting me and making me think if I should go to graduate school or not. So, it's yeah, they definitely impact me by making me considerate. You know whereas before when I was first just going to school, I was just thinking of just getting the undergraduate degree, getting a good analyst job and cybersecurity. And then, you know, finishing from there but I'm considering graduate school in the future for sure. If the difference between the pay of graduate and undergraduate degree is high and if I can somehow get away from paying, then it is possible. Yeah, I would definitely go to get a master's or PhD if it means that much of an increase in pay... Because yeah, I think that would be you wind up making more money in the long run because. If you do get the analyst job. So yeah, I'd probably go for the master's degree if I can get it paid, or even if I do have to pay. And it's not too much money. So, for me it'd be a no brainer, honestly.

**Interviewer.** Are you worried about how you're doing the classes that you are enrolled in?

**RP 1.** Yes, very much so, very word... I would say I would almost never get bored, but it does happen sometimes, but generally I am not bored...the material in the class if the content really isn't like applicable, you know, I would generally always try to find material that's applicable to me. I'm usually pretty good at that, but sometimes it's like, you know, the material just can be very dry and stuff. So it does, you know, impact you and get you a little bored or sometimes it's like if you're worried about other assignments, you're not really thinking about. Sometimes it's just more beneficial to work on other class material than actually listen to a lecture.

The following RP is another member of the minority that didn't have worries about doing well in the classroom.

**Interviewer.** Do you believe there are factors that impact how well you do in the classroom and if you choose from this list here?

**RP 2.** Yeah. I am a member of the minority, but in computer security it doesn't feel as if because it's very diverse so, maybe, maybe not the first one. I don't think it impacts me too much, but maybe in the general screen scheme not talking cyber cybersecurity, it can impact me. Yes, I want to make a lot of money. Yes, I am the first generation in my family that attends a college to complete a degree. Yes, I want a good job with good pay one day. Yes, I'm excited to solve some of the cyber security problems in real life. Yes, some of my professors motivate me to continue my degree. And yes, the course concepts motivate me a lot.

**Interviewer.** Are you worried about how you do in the classes that you are enrolled in?

**RP 2.** It is very rare, almost no. Sometimes it would be if the classes are online or if it's in person. If it's online, maybe I'll be a little worried to see how the semester will go. Sometimes it's the number of classes I'm taking. If I'm taking over the number of credits. Taking like over full-time credits, I think it's over like 15 credits. I'm taking 19 credits next semester, so sometimes. I'll think like how can I do this at this time? But that's what I'd be worried about a little bit.

The third response example of the RPs we provide stated that solving real life problems is exciting and it is a factor that impacts doing well in the classroom who also worries about doing well in the courses.

**Interviewer.** Do you believe there are factors that impact how well you do in the classroom and if you choose the ones that apply here in this list, which ones would you choose?

**RP 3.** Honestly, I get really excited about solving real-life cybersecurity problems. What we're learning right now is mostly theory, which is great, but I really enjoy the hands-on stuff—like doing labs in class. That's where it all starts to make sense for me. Internships are a huge part of it too. They give you real-world experience that you just can't get from theory alone. It's one thing to learn something in class but actually using that knowledge in real situations is completely different. That's actually one of the reasons I want to be a cybersecurity analyst. I want to take what I'm learning now and apply it to real-world problems. So yeah, for me, it's all about the hands-on experience—whether it's labs, internships, or solving actual problems. That's what really helps me do better in the classroom and gets me motivated.

**Interviewer.** Are you worried about how you doing classes that you're all?

**RP 3.** Yes, of course I do. Whenever I'm taking classes, I always want to get an A. I try my best, but sometimes it doesn't work out the way I hope. Even when it's tough, I push myself to keep going and do the best I can in each class. I try to stay on top of things by finishing assignments as early as possible and really focusing on learning the material. If I struggle with anything, I make it a point to talk to my professors. They've been super helpful—when I let them know I'm not understanding something, they're always willing to help. They'll say, "Don't worry, come to my office hours, and we'll go over it." That kind of support really makes a difference. So yeah, I do worry about how I'm doing in my classes, but I've been managing pretty well so far, and I'm happy with the progress I'm making.

As demonstrated by the examples of the transcribed follow-up video recorded responses, the qualitative results agreed with the quantitative results with furthermore justification of the participants' written survey responses. One of the major outcomes from this analysis is the highest cross correlation between the worry levels of how students do well in the classroom and their desire to have a good job; this may be due to participants' higher desire to have a good job resulting in higher stress levels and worries on doing well in the classroom. Looking at the qualitative analysis of the data, the correlation between participants who want to solve challenging cybersecurity students appear to believe that they need to do well in the classroom in order to be well prepared for solving challenging real-world cybersecurity problems.

## CONCLUSIONS AND FUTURE WORK

In this heuristic study we presented results on factors that impact undergraduate cybersecurity students in the classroom that are also serving as motivational factors for them to be in the cybersecurity field and their worry levels. The data is collected from 103 students at a university located in the Northeastern side of the United States with the quantitative data including statistics, mathematical model fitting, correlation with heatmap evaluation, cross-correlation, and Mann-Whitney U-test while qualitative analysis relied on the transcribed video recordings of the participants that aimed to follow-up to their answers to the research questions. Participants are compensated with money for participating in the video recorded interviews with the PI. Part A part of the research focused on the factors that impact how well cybersecurity students do in the classroom. Figure VI demonstrates a summary of the statistics and categories that the cybersecurity students chose for Part A.

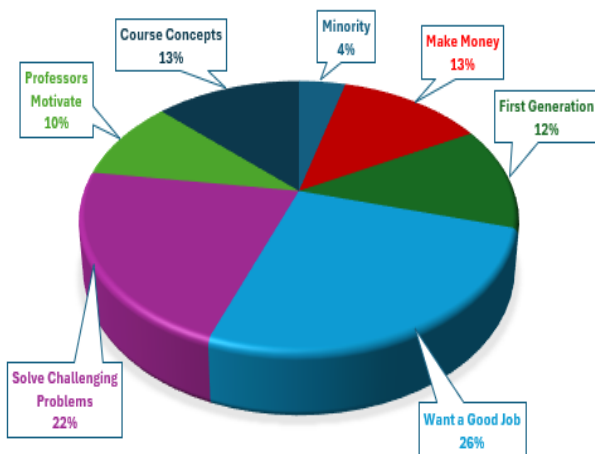


FIGURE VI

PART A'S DATA DISTRIBUTION OF PARTICIPANT CHOICES

The following key results are attained through the analysis of quantitative and qualitative results:

- Among the list of Part A choices of the participants, wanting a good job is determined to be the number one choice by the participants with a percentage of 26.29% based on the quantitative responses. Solving challenging problems placed second with 21.65% of the participants' interest. Making money and course concepts are determined to motivate students at the same level of percentage, 12.89%. A percentage value of 12.37% is attained for the option of being the first generation in the family who goes to college. The last option selected is determined to be the minority with 4.12% of the participants selecting this option.
- Quantitative analysis to Part A indicated a high correlation range varying from 60 to 66% for five of the seven Part A options stating that most of the participants' choices correlated for these five variables

as demonstrated in Table I. The highest correlation average value of 65.6% is attained within the group of making money meaning the highest correlation average of choices occurred with other options in this group. The lowest average of 44.31% and the corresponding standard deviation of 14.25% are attained for those who wanted to make money.

- Part B of the research focused on the worry levels as a counter factor to the Part A responses as such factors can demotivate students to do worse in the classroom depending on the levels of worries. The quantitative results indicated about two thirds (i.e. 67%) of the participants are worried about how they do in the classroom while 27% mentioned it to be sometimes and 6% of the participants are not worried about it at all.
- A cross-correlation evaluation of the responses to Parts A and B resulted in the highest worry levels of the participants to be for those who want to have a good job one day with the second highest correlation to worrying how well they do in the classroom being the desire to solve challenging problems.
- After categorization of the group data into responses given to Parts A and B as two separate groups, the Mann-Whitney U test indicated no statistically significant difference between the responses given to Parts A and B at a level of  $\alpha=0.01$  confidence level.
- The qualitative results agreed with the quantitative results with furthermore justification of the participants' written survey responses. One of the major outcomes from this analysis is the highest cross correlation between the worry levels of how students do well in the classroom and their desire to have a good job; this may be due to participants' higher desire to have a good job resulting in higher stress levels and worries on doing well in the classroom. Looking at the qualitative analysis of the data, the correlation between participants who want to solve challenging cybersecurity students appear to believe that they need to do well in the classroom to be well prepared for solving challenging real-world cybersecurity problems.

The results presented in this work can be impactful in curriculum design decisions and teaching materials prepared for lecture coverages of courses; Such decisions to be made can rely on educational accommodation for students based on their needs to be able to work with them by providing flexibility.

We invite other researchers and educators to take part in this underdeveloped and important pedagogical research area as there is a major need for more undergraduate students taking part in cybersecurity professional roles in addition to the future educators that we need in this field. The results attained in this research can be further used for improving not only the cybersecurity classroom environment but also improving our educational methods and course designs by incorporating the students in the development of courses.

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