WIP: Exploring the viability of a Bi-directional Skill-Based Mentoring Program on Communication Skills for Graduate Students in Education and Computer Science Students.

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***Abstract*— Due to the increasing interest in integrating data into various instructional decisions, data science skills have become important to promote in Ed.D. students. Meanwhile, there is a similar increase in interest in improving communication skills among engineering students. The needs of these two communities open room for an exchange of skills and mentoring opportunities. Bi-directional, two-way mentoring emphasizes the reciprocal exchange of knowledge, skills, and experiences between mentors and mentees, transcending traditional hierarchical relationships. While these two communities could benefit from each other by helping their counterpart acquire or improve their respective skills, two elements must exist for bi-directional mentoring to be effective: commitment and recognition of each other's value. Therefore, in this research-to-practice WIP article, the researchers explore computer science students' perceptions of the importance of communication skills and the value they see in mentors helping them gain these skills. Mainly, we address the following research questions:

RQ1: To what extent do computer science student value communication skills in their academic and future professional pursuits?

RQ2: To what extent do computer science students value mentoring to learn and develop communication skills?

RQ3: Is there a difference in the value that computer science students pose in learning and developing communication skills with and without mentoring?

To answer these questions, we distributed a survey in two different classes at two different institutions in a southeastern region of the US in Spring 2024. In this WIP paper, the researchers present the results of the computer science students' values related to participating in a bi-directional mentoring program to learn communication skills. Overall, students value communication skills and know their critical role in their future. This is shown by high-scale scores obtained in mentoring for communications skills.

Keywords— communication skills, mentoring, computer science, schoolteachers.

I. INTRODUCTION

In engineering and computer science, professionals are tasked with understanding and solving problems and delivering solutions to stakeholders. In these practices, communication skills become crucial for understanding problems and sharing solutions with stakeholders. In an era of globalization, engineers and computer scientists must develop excellent communication skills to collaborate effectively with other teams [1]. In addition, with the growing interest in data science and the need for promoting and developing data-related skills, helping train K-12 educators and administrators holds potential for creating a data culture among the new generations of students. Yet only 17% of teachers receive data training [2], and while mentoring programs have shown potential in training critical school staff, the scalability of these programs presents a challenge [3].

Bi-directional mentoring, or two-way mentoring, emphasizes the reciprocal exchange of knowledge, skills, and experiences between mentors and mentees, transcending traditional hierarchical relationships [4] and therefore making for scalable solutions. We hypothesize that computer science students and graduate students in education are two communities that could benefit from a bi-directional mentoring program by helping their counterparts acquire or improve their respective skills. However, two elements must exist for a bi-directional mentoring program to be effective: commitment and recognition of each other's value. Some researchers have explored attitudes toward learning and developing communication skills [5], however, there is still the need to examine whether or not students see value in developing communication skills and engaging in mentoring programs and how two different communities can exchange expertise and experiences for mutual benefit.

Therefore, in this WIP research practice paper, we focus on exploring whether computer science students see value in a mentoring program that promotes communication skills by participating in bi-directional mentoring. No program has been implemented yet; instead, the researchers examine the feasibility of implementing a Bi-directional mentoring program between graduate students in education and computer science students. Mainly, we address the following research questions:

> RQ1: To what extent do computer science student value communication skills in their academic and future professional pursuits?
>
> RQ2: To what extent do computer science students value mentoring to learn and develop communication skills?
>
> RQ1: To what extent do computer science student value communication skills in their academic and future professional pursuits?

II. Literature review

A. Mentoring Programs in Engineering

Mentoring programs provide a pathway for fostering the success of diverse engineering skills [6]. When mentoring programs are integrated with engineering practices, professional and personal growth is enhanced [7]. For instance, prior literature had identified the instrumental role of mentoring in integrating cognitive apprenticeship [8], improving students' prospects for jobs [9], and benefiting both mentors and mentees [10], as it gives opportunity to students to learn from other fields and codevelop different skills [11]. Mentoring programs were even more beneficial during COVID-19 as they provided not only mentoring support to students but also support for their mental health [12].

Regardless of the mentoring programs benefits, mentoring programs that target communication skills are still difficult to integrate with curricula due to the engineering and computing overloaded curriculum. Prior literature has shown that studies that students can benefit from cocurricular activities that enhance soft skills such as communication skills [7].

III. Conceptual Framework

To evaluate the extent to which computer science (CS) students value communication skills through mentorship, we use the Expectancy Value Theory (EVT). EVT was developed by achievement motivation theorists [13] and proposes that individuals' beliefs about how well they perform on a task and the value of the activity can be explained by an individual's choice, persistence, and performance [13]. In our study, examining the feasibility of extending students' value to develop communication skills and developing them through mentoring are the two factors examined through the lenses of the EVT. One factor will focus on Expectancy belief, and the second factor is task value.

A. Expectancy Beliefs

The expectancy belief informs how well students believe they will do in developing communication skills. This component aligns with self-efficacy theories.

1) Self-efficacy

Self-efficacy is defined as students' confidence in completing a task. In this study, this definition is following the work of Bandura [14] and Pajares [15].

B. Task Value

Another component in our conceptual framework is Task Value. Task Value refers to the perceptions individuals have towards a task, whether the task is useful, important, or enjoyable. Eccles [16] suggested four components in task value: Attainment Value, Utility Value, Intrinsic Value, and Cost.

1) Attainment Value

Attainment Value is defined by Eccles [16] and Battle [17]as the importance placed on completing a specific task well.

2) Utility Value

Utility value is defined as how an individual perceives the usefulness of a task for their future goals [13]. Utility Value captures the extrinsic reasons an individual would engage in a specific task.

3) Intrinsic Value

Intrinsic value is defined as the individual's enjoyment and interest in doing a specific task.

4) Cost

Cost is defined as how individuals decide and perceive the limits of access to other activities if they were to engage in a specific task. These negatives can be related to time, effort, and potential stress associated with a specific task.

IV. Methods

This section is structured to provide a comprehensive overview of our methodology. Initially, we will outline the design of the instrument employed in the study. Subsequently, we will detail the setting and the demographic characteristics of the participants involved. The process of data pre-processing will be explained to ensure clarity on how the raw data was refined for analysis. Lastly, we will describe the statistical methods utilized to examine the data, specifically focusing on exploratory factor analysis and descriptive statistics to elucidate the underlying patterns and trends.

A. Instrument development

The objective of this instrument was to assess computer science students' perceptions of the importance of communication skills and their valuation of a mentoring program designed to enhance those skills. Namely, the extent to which they value communication skills in their academic and future professional pursuits (CSV), and the extent to which they value mentoring for learning and developing communication skills (MCSV). The instrument was constructed using two primary factors and six subfactors from a framework proposed by Wigfield and Eccles [13]. To maintain brevity and focus, we crafted two questions for each subfactor to measure CSV and another two for assessing MCSV. These decisions resulted in 24 questions. Each question was phrased as a positive statement, and responses were captured on a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) [18]. Additionally, to the 24 questions corresponding to the framework, one question was added to fulfill an instructional manipulation check role as proposed by Oppenheimer [19]. Question 19: *In this survey about mentoring and communication skills, I am thoughtfully replying to each question.* Question 19 was provided to help keep responses from students responding to the questions thoughtfully.

B. *Context and participants*

In Spring 2024, the survey was administered in a sophomore-level computer science course at a large, public, research-intensive university in the southeastern United States. This mandatory course, primarily attended by computer science and computer engineering majors, focuses on understanding computer architecture. During the semester, approximately 550 students were enrolled in the course. The instrument was distributed in week 12 of the semester using Qualtrics [20], and extra credit was provided to students who completed the instrument.

C. *Statistical analysis*

Initially, Bartlett's chi-square test [21] and Kaiser-Meyer-Olkin (KMO) test [22] were conducted to assess the suitability of data for EFA by examining the correlation among variables and measuring sampling adequacy. EFA is implemented using the Factor Analyzer library in Python 3.11 [23]. The analysis involves applying a varimax rotation, a method chosen to simplify the loadings of factors on the variables by maximizing the variance of squared loadings per factor [24]. We fixed the rotation and iteratively assessed the results with different numbers of factors until a clear structure was achieved, characterized by significant loadings and minimal cross-loadings. This iterative approach ensures the extraction of meaningful factors that accurately reflect the underlying patterns in the data.

After examining the structure of the tool, we'll delve into the significance of communication skills and learning them through mentorship. Each construct's measurement will be determined by calculating a score based on the sum of its items divided by the total number of items, then multiplied by five. We analyze RQ1 and RQ2 using descriptive statistics, with a focus on using boxplots. To address RQ3, we employed a paired Wilcoxon Signed-Rank test to compare scores between the two constructs. This test is suitable for comparing Likert scale scores, and it is particularly effective for paired data, as in our case where the same students were surveyed. We utilized Python libraries such as pandas, matplotlib, seaborn, and SciPy.Stats to conduct the analysis and generate the visualizations.

V. Findings

Among the 550 students enrolled, 406 participated in the survey, and 364 provided complete responses. However, 42 left over 60% of the survey unanswered. An instructional manipulation check confirmed that 287 respondents were engaging thoughtfully with the survey. This subset of 287 students was used for the statistical analysis to explore the instrument's internal structure.

We hypothesized that the instrument comprised two main constructs, each divided into two factors and four sub-factors (see Fig. 1). To test this structure, we categorized the questions into two groups: one related to communication skills and the other to mentorship in communication skills. Items pertaining to control beliefs showed poor performance, evidenced by cross-loadings and weak correlations. Consequently, four items (Q5, Q6, Q7, Q8) were excluded from further analysis due to inconsistencies in their wording that could affect both external and internal validity.

The analysis results, presented in Tables 1 and 2, confirmed the hypothesized structure of the instrument. With this validated structure, it is feasible to compute a value score for each construct, ensuring the instrument's alignment with theoretical expectations.

Table 1: Exploratory factor analysis for the items corresponding to mentoring

	F1	**F2**	**F3**	**F4**	**F5**
Q3	0.21	-0.06	0.02	0.15	0.89
Q4	0.17	-0.08	0.14	0.24	0.85
Q11	0.80	-0.11	0.31	0.19	0.23
Q12	0.79	-0.05	0.26	0.26	0.24
Q15	0.11	-0.01	0.17	0.87	0.21
Q16	0.28	-0.04	0.06	0.84	0.17
Q19	0.16	-0.09	0.92	0.06	0.07
Q20	0.36	-0.02	0.80	0.19	0.09
Q24	-0.15	0.83	-0.05	-0.01	-0.14
Q25	0.03	0.88	-0.04	-0.03	0.01

Table 2: Exploratory factor analysis for no mentoring items

	F1	**F2**	**F3**	**F4**	**F5**
Q1	0.09	0.01	0.90	-0.03	0.07
Q2	0.21	0.17	0.81	-0.12	0.12

Q9	0.90	0.02	0.08	0.00	0.20
Q10	0.83	0.09	0.24	-0.14	0.23
Q13	-0.01	0.89	0.09	-0.11	0.08
Q14	0.11	0.89	0.08	-0.09	0.09
Q17	0.14	0.21	0.06	-0.06	0.89
Q18	0.37	-0.02	0.16	-0.13	0.79
Q22	-0.08	-0.05	0.02	0.85	-0.19
Q23	-0.03	-0.15	-0.16	0.84	0.03

From the results obtained from the EFA, the following scores characterize the two constructs to measure: CSV is equal to the sum of the answers in Q1, Q2, Q9, Q10, Q13, Q14, Q17, Q18, Q22, and Q23 divided in 50, MCSV results from the addition of the answers in Q3, Q4, Q11, Q12, Q15, Q16, Q19, Q20, Q24, and Q25 divided by 50. The 50 used in both scores corresponds to the normalization of the score. Particularly, there are ten questions in each scale, and all of them have a value between zero and five.

A. *RQ1: TO WHAT EXTENT DO COMPUTER SCIENCE STUDENT VALUE COMMUNICATION SKILLS IN THEIR ACADEMIC AND FUTURE PROFESSIONAL PURSUITS*

From Fig 1, we can deduce that students generally place a high value on communication skills valuation (CSV). For instance, Equation 1 was used to calculate CSV yield scores from 0.5 to 1, with the median score being 0.75. This distribution indicates that most surveyed students recognize the importance of communication skills, as evidenced by the score's concentration towards the upper end of the scale.

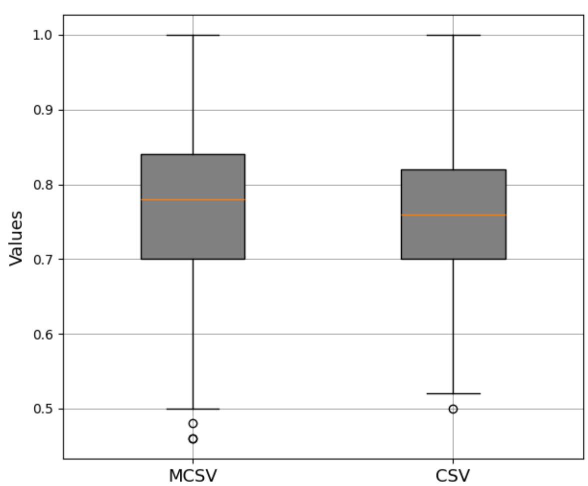

Fig 1. Boxplot showing the distribution of MCSV and CSV (n = 287). CSV stands for the value of communication skills in their academic and future professional pursuits, and MCSV stands for the value of mentoring to learn and develop communication skills.

B. *RQ2: TO WHAT EXTENT DO COMPUTER SCIENCE STUDENTS VALUE MENTORING TO LEARN AND DEVELOP COMMUNICATION SKILLS?*

The calculation of the score for mentoring communication skills valuation (MCSV) is derived from a specific equation. Analysis of this score reveals that like communication skills valuation (CSV), students also highly value MCSV. Notably, the median score for MCSV is approximately 0.8, indicating a slightly higher valuation than CSV. Furthermore, only a minority of scores fall below 0.5, suggesting that the overall appreciation for mentoring in communication skills is robust among students.

C. *RQ3: IS THERE A DIFFERENCE IN THE VALUE THAT COMPUTER SCIENCE STUDENTS POSE IN LEARNING AND DEVELOPING COMMUNICATION SKILLS WITH AND WITHOUT MENTORING?*

From the observation of Fig 1, it is possible to see that the distributions for CSV and MCSV are similar. Nonetheless, MCSV has a higher median than CSV. In addition, the distribution of MCSV is broader than that of CSV.

From the Wilcoxon rank procedure, the statistics were equal to 15116.5, and the p-value was 0.18. With these results, we conclude that we do not have enough evidence to reject the null hypothesis, which would have significant differences in this case.

VI. Discussion

The discussion of this exploratory study focuses on the insights drawn from applying the Expectancy Value Theory (EVT) to understand the perceived value of communication skills among Computer Science (CS) students. A core finding is that EVT effectively highlights the importance of communication skills alongside the value students place on mentoring to enhance these skills. This aligns with studies such as [1][2] emphasizing the need for such skills as identified by industry stakeholders yet extends the discussion by focusing directly on student perceptions.

Firstly, the analysis of control beliefs within the EVT framework [13] demonstrated weaker performance. Upon further examination, it became evident that students differentiate between external and internal factors when evaluating their control over acquiring communication skills. This nuanced perception necessitates a refinement of the EVT items in future studies to better capture these distinctions.

Secondly, the results clearly indicate that CS students value communication skills highly. This finding is significant as it confirms earlier research and emphasizes the intrinsic value placed on these skills by the students themselves. This intrinsic valuation suggests a strong foundation for further educational interventions to enhance communication skills within CS curricula.

Lastly, an intriguing parallel was observed between students' value of communication skills and the value they assign to mentoring in acquiring these skills. This parallel invite further research into the potential synergies between mentoring and skill acquisition in the specific context of engineering education, such as bi-directional mentoring [5], where such dynamics have been underexplored.

VII. CONCLUSIONS

This working-in-progress study explored the viability of a bi-directional mentoring program that targets providing mentoring to computer science students to develop communication skills, and graduate students from education to develop data science skills. In this work in progress, we present only computer science students' value to mentoring and communication skills to evaluate the viability of the bi-directional mentoring program. Our findings indicate that students recognize the importance of developing communication skills, as well as there is not enough evidence to identify difference between the value of students have with and without mentoring.

VIII. LIMITATIONS AND FUTURE DIRECTIONS

This working progress study's main limitation is the only focus on computer science students, while it poses an important picture of the viability of a bi-directional program. It does not provide the full picture. Future work will compare the value of graduate students in a doctoral program and compare them with computer science students. Finally, our instrument will collect evidence for validity, to use in other settings.

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