A Summary of Key Findings

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The analysis is based on quantitative and qualitative data collected in fall 2017-summer 2018. Publications in peer-reviewed journals will be based on the entire dataset which includes data collected in fall 2018 as well.

Project Title: Enhancing Aspiring Cybersecurity Professionals Writing Skills: An Evaluation of Student and Work Force Needs for Program Improvement

Study Participants

203 Computer Science students enrolled at a 4-year public university and community college in Western Pennsylvania completed electronic surveys administered in class.

- Freshman (n = 25, 12.3%)
- Sophomore (n = 56, 27.6%)
- Juniors (n = 56, 27.6%0
- Seniors (n = 65, 32%)

27 professionals engaged in cybersecurity work participated in semi-structured interviews.

- IT trainers/analysists (n =10, 37%)
- IT directors/managers (n = 5, 10%)
- Software engineers/programmers (n = 5, 10%)
- Network/System administrators (n = 4, 15%)
- IT tech. support (n = 2, 7%)
- IT faculty/teachers (n = 1, 4%)

Data Sources and Instruments

Data from three different sources were used to answer the different research questions. Details about each are listed below.

1. The survey protocol includes 14 questions. Items 1–7 elicit the following data from survey respondents: class standing, gender, spoken language/s, college major, and potential future careers. Questions 8–10 required survey respondents to identify the courses they found helpful in high school and those they would have liked to take to be successful as a computer science professional. Item 11 assesses survey respondents' beliefs about the importance of writing skills and oral skills in the fields of computer science and cybersecurity. Items 12–13 examine survey respondents' beliefs about oral and writing skills, use of feedback in improving these skills, and resources that they used to improve their writing. Finally, item 14 requires survey respondents to describe the number of times they visited the different writing center sites for tutoring. The survey is publicly available, as per the stipulations of the grant, at: https://www.iup.edu/compsci/events/cae-c-expansion/research-study/

2. The interview protocol includes 17 core questions. Item 1 explores the nature of the interviewees' jobs. Items 2–6 assess the interviewees' past and current writing experiences.

Items 7–9 elicit data related to the interviewees' oral presentation skills. Items 10–13 elicit data related to interviewees' beliefs about important skills for a colleague and recommendations that would enhance undergraduate computer science students' learning. The last four items, 14–17, elicit interviewees' demographic information and request for the interviewee to review the interview transcript. The interview protocol is publicly available, as per the stipulations of the grant, at: https://www.iup.edu/compsci/events/cae-c-expansion/research-study/

3. The Writing Center provided a third source of data – 107 Anonymized Student Jot Reports. This data in each report summarizes the writing or oral communication skills Computer Science students worked on during scheduled tutoring sessions.

Research Question 1: Which technical courses (past and current) did aspiring cyber security professionals identify as valuable?

Survey item 8 was designed to elicit data related to technical coursework students took in high school. Only 88 percent of the aspiring cybersecurity professionals, answered this question. The qualitative data were quantized to identify patterns. A fourth identified programming courses such as Java, C++, C#, Python, Basic, etc. as valuable (n = 52; 25.6%). The rest, who may not have had access to programming courses, identified non-computer science courses (n = 72; 35%), Math courses like Calculus, Algebra, Physics etc. (n = 22; 10.8%), Computer Aided Design, Networking, Maintenance (n = 12; 5.9%), Web Design and Development (n = 11; 5.4%), and MS Office Applications like MS Office (n = 9, 4.4%) as valuable.

Survey item 9 elicited qualitative data related to the courses aspiring cybersecurity professionals would like to have take in high school, in retrospect, to enhance their ability as computer science professionals. The qualitative data were quantized to identify patterns. The majority indicated that they would have liked to take programming (Java, C++, C#, Python, Basic, etc.) courses (n = 123, 60.6%). Others indicated that would have liked to take Computer Science related courses (n = 25, 12.4%), Computer Aided Design (CAD) (n = 14, 6.9%), Math courses like Calculus, Algebra, Physics, etc. (n = 6, 3%), Web Design/programming (n = 3, 1.5%), and Office Applications (MS Office and alike) (n = 2, 1%).

Survey item 10 was designed to elicit aspiring cybersecurity professionals' attitude towards three technical college courses. A five-point Likert scale was used to collect data, with 1 being not important and 5 being extremely important. The majority rated Software Engineering (n = 161; 80.5%), Databases, Operating Systems (n = 159; 79%), and Computer Networks (n = 153; 76%) as very to extremely important.

Research Question 2: How do aspiring cybersecurity professionals describe their present skill level in terms of writing and communication? Are there group differences based on gender, student status (freshman, sophomore, junior, senior), linguistic background (mono/bilingual/multilingual, and school type)?

Survey item 11 evaluated aspiring cybersecurity professionals' perceptions about the importance they, as Computer Science students, placed on oral and written communication skills. A six point Likert scale was used to collect data, with 1 being strongly disagree and 6 being strongly agree. A large majority slightly to strongly agreed that writing skills (94.1%) and oral skills (93.5%) were important.

Survey item 12 required aspiring cybersecurity professionals to evaluate their proficiency in terms of seven different writing skills and two oral skills. A six point Likert scale was used to collect data, with 1 being strongly disagree and 6 being strongly agree.

- On average, 82.2% slightly to strongly agreed that they found it relatively easy to use information from sources in their writing (M = 5.46, SD = 1.188). Similarly, 80.7% slightly to strongly agreed they wrote effectively for people with technical knowledge about the field (M = 5.22, SD = 1.133). Survey respondents were less confident about the other five skills.
- A smaller proportion of survey respondents slightly to strongly agreed that they write effectively for people without technical knowledge of my field (77.4%, M = 5.12, SD = 1.311), people say their writing is clear (75.9%, M = 5.43, SD=1.223), and they use feedback to improve their writing (75.8%, M = 5.56, SD = 1.135).
- Fewer survey respondents slightly to strongly agreed that they seek feedback about drafts of their writing (71.4%, M = 5.13, SD = 1.392), and use proofreading techniques to ensure that their work has no errors (71.0%, M = 5.30, SD = 1.236).
- A little over seventy percent of the survey respondents slightly to strongly agreed that people commented positively about the visual aids they created for oral presentations (71.9%, M = 5.07, SD = 1.466) and their oral delivery of speeches and presentations (70.4%, M = 5.06, SD = 1.400).
- A series of *t*-test and one-way ANOVA tests revealed that group differences based on gender, student status (freshman, sophomore, junior, senior), and linguistic background (mono/bilingual/multilingual, and school type) were not statistically significant.

Research Question 3: What kinds of writing do practicing professionals engaged in cybersecurity do most often? What challenges, if any, do they face (writing type, writing skills)?

During the semi-structured interviews practicing professionals indicated that they engaged in the following types of writing, on a on a regular basis.

- Email (n = 26, 96%)
- Reports (n = 12, 44.5%)
- Procedures (n = 10, 37%)
- Documentation (n = 9, 33%)
- Training modules (n = 6, 22%)
- Memos (n = 4, 15%)
- Texts/apps (n = 4, 15%)

Other writing types that they referenced less frequently include: pictures, policy, PowerPoints, webpages, checklists, and curriculum.

Practicing professionals identified the following writing challenges:

- Grammar (style, sentence structure, flow, spelling, incomplete sentences, word choice, details, tense, point of view) (n = 16, 59.26%,)
- Technical language (n = 16, 59.26%)
- Proofreading (n = 8, 29.6%)
- Format (n = 7, 25.9%)

Other writing challenges that they referenced less frequently include: acronyms, conveying meaning through writing, putting ideas into writing, academic writing, vocabulary, and technical difficulties.

Practicing cybersecurity professionals identified the following oral communication challenges:

- Connecting to audience (confusion, frustration, losing attention, intimidation) (n = 8, 29.6%)
- Technical language (n = 6, 22.22%)
- Being concise (n = 6, 22.22%)
- Adjusting to different audiences (n =5, 18.51%)
- Anxiety (n = 5, 18.51%)
- Acronyms (n = 4, 14.81%)
- Confrontation (n = 4, 14.81%)

Research Question 4: What resources should the Writing Center and Computer Science Professors offer to better meet the needs identified by aspiring and practicing cybersecurity professionals?

Survey data were coupled with qualitative data from the following sources to answer this question:

1. Semi-structured interview data with 27 practicing professionals engaged in cybersecurity work;

2. The Jot Report data that summarized the skills undergraduate Computer Science students worked on during scheduled tutoring sessions.

Survey data revealed that aspiring cybersecurity professionals would would benefit from resources that help them to write more clearly. This includes writing for people with and without technical knowledge of the field. Jot Report data helped identify skills that most of Computer Science undergraduates worked on during tutoring session. These included: punctuation (n = 64), word and sentence errors (n = 61), voice and style (n = 52), organization (n = 45), transition and flow (n = 41), formatting documents (n =32), developing ideas (n = 25). During the semi-structured interviews with the 27 practicing professionals, a fair number indicated that they were challenged by the areas identified. They suggested that the Writing Center should offer workshops and tutoring sessions on technical writing (documentation, procedural writing, business writing, writing directions, resumes memos) as well as workshops on writing professional emails.

Practicing professionals also indicated that Writing Centers need to do a better job in terms of explaining what services they provide. They explained that this could be accomplished in several ways. For example, Writing Center staff visit Computer Science classes to inform them about the services they provide. They could clear misconception that students may have
To accommodate the writing and oral communication needs of both groups, Writing Center tutors, who had received specialized training, conducted 107 tutoring sessions during the grant funded period. Additionally, the Writing Center Director (co-PI) and Tutor (graduate assistant) provided Computer Science professors at the 4-year public institution with instructional resources that target the identified areas listed below:

1. Self-Assessments: sentence structure self-assessment, paragraph organization self-assessment, technical versus nontechnical language self-assessment, sentence structure self-assessment;
2. Help Sheets: correcting for subject-verb agreement help sheet, using transitional words and phrases help sheet, correcting fragments, run-ons, and comma splices help sheet, proofreading your writing help sheet, using formal vs. informal language help sheet, writing for your audience help sheet; using inclusive language help sheet, planning a problem-solution essay help sheet, understanding Grammarly help sheet, writing thesis statements help sheet, writing effective introductions help sheet);
3. Citing Help Sheets: using MLA style help sheet; citing sources using APA style help sheet;
4. Videos: understanding assignments video; understanding the rhetorical situation video, APA video; MLA video;
5. Workshops: To support aspiring and practicing professionals' oral challenges the Writing Center designed two workshops. The first targeted the development of effective PowerPoints. The second was titled "Get Your Grammar On."

These resources are publicly available, as per the stipulations of the grant at: https://www.iup.edu/compsci/events/cae-c-expansion/writing-and-communication-skills-tutoring/

During the semi-structured interviews, the 27 practicing professionals offered recommendations to guide Computer Science professors' work in this area. Ten interviewees recommended that

professors integrate communication skills in courses. Interviewees also identified other ways in which students writing, and communication skills could be further enhanced. They suggested that Computer Science professors embed real world opportunities into their respective courses so that students could work at help desks, develop project proposals, pitch projects, and work on case studies (n -7). Others suggested that professors should require students to deliver formal in class presentations more frequently (n = 6). They also suggested that professors should explicitly teach students presentation skills. They indicated that this direct instruction should include, among other things, the best way to explain jargon, perspective, and highlight benefits.

Research Question 5: Does extant data, collected by the Writing Center, show an increased use of the services they offer undergraduate Computer Science students over the grant funded period?

Data collected by the Writing Center revealed a steady increase in the number of tutoring sessions scheduled by Computer Science students between August 2017 and May 2018. As evident from Table 1 the 107 many of the tutoring sessions were scheduled prior to mid-term and final examinations.

Table 1.

Computer Science Initiated Writing and Communication Sessions

Month	Number of Tutoring Sessions
August 2017	0
September 2017	8
October 2017	2
November 2017	24
December 2017	27
January 2018	0
February 2018	14
March 2018	16
April 2018	16
May 2018	0
Total	107

Note. These sessions were offered at the 4-year public institution at 4 different locations.