Proceedings of the 10th Colloquium for Information Systems Security Education
University of Maryland, University College
Adelphi, MD June 5-8, 2006

An Academic Perspective on the CNSS Standards: A Survey

Carol Taylor, *Member, IEEE,* Jim Alves-Foss, *Senior Member, IEEE* and Valerie Freeman, *University of Idaho*

Abstract –In this paper we examine the Committee on National Security Systems (CNSS) 4011-4016 family of standards for high assurance academic programs. Currently, institutions that apply for the NSA Center of Academic Excellence in Information Assurance Education (CAEIAE) or Information Assurance Courseware Evaluation (IACE) designation must map their curricula to the CNSS standards. We survey academic institutions that have earned either the CNSS CAEIAE or IACE about their experiences in performing the mapping. Prior investigation and personal experience with the mapping process suggest the standards may not be appropriate for college computer security programs since they were developed as government training standards. The goal of the survey is to gather information from other institutions that demonstrate the adequacy of the standards or document any perceived shortcomings. This information should prove useful to support continued use of the CNSS standards as is, recommend improvements or suggest that alternative standards might be warranted.

Index terms – Computer Security, Computer Science Education, Curriculum, Training Standards

I. Introduction

Thirty years ago computer security consisted of a small group of mostly self-educated researchers and practitioners whose main focus was the confidentiality of government data. The major problems of that time were multi-level security, covert channel analysis and the development of high assurance systems. Formal methods were prevalent in proving the security of these systems as was the use of encryption and mandatory access control. The primary consumer and funding agency of computer security research at that time was the military.

Since the 1970's, computer security has progressed as both an area of research and as a sub-discipline within computer science. There are defined career paths for computer security professionals and many professional certification and academic degree programs that specialize in security education. The research focus has broadened to include a multitude of topics related to e-commerce, user security and privacy, digital forensics and critical infrastructure protection.

Carol Taylor, Research Scientist, University of Idaho
Jim Alves-Foss, Associate Professor, University of Idaho

This growth within computer security parallels computer use within our society since computers have become the foundation upon which our national security and industry depends. In response to the recognition of the importance of computer security, the US government in 1998 tasked the NSA with the responsibility of establishing and managing the Centers of Academic Excellence in Information Assurance Education (CAEIAE) [1]. The purpose of the centers is to increase the number of students entering the information assurance profession and to become established centers of computer security knowledge.

The CAEIAE program has continued to grow from a core of seven initial institutions to 67 schools spread across 27 states as of 2005 [2]. Recently, the NSA has decided to recognize those schools that have not qualified or applied to be a CAEIAE but have performed the mapping of the CNSS standards to their curricula [3]. Currently, over 150 schools have passed the CNSS IA Courseware Evaluation Program (IACE) which requires the school to map its curriculum to the 4011 standard plus at least one other standard from the remaining 4012 - 4016 [3]. Included in this recognized group are the CAEIAE institutions which must pass the IACE program as a first step to becoming a CAEIAE.

Designating institutions as meeting the curriculum requirements for a CAEIAE or the less stringent CNSS IACE program certifies that the curriculum meets a minimum set of security requirements. Schools that successfully map their courses to the CNSS standards are assured to teach certain security concepts and practices. However, because the CNSS standards are primarily aimed at government employees, there is concern that these standards are not best suited to college-level academic programs. A paper we presented at CISSE 2005 documents some of the problems with the CNSS standards [4]. The present paper discusses difficulties experienced by institutions mapping undergraduate courses to a set of professional training standards.

As a result of our experience in performing the mapping and feedback from the CISSE 2005 paper [4], we decided to survey other schools involved in the mapping to document their experiences. Survey goals were twofold:

- Record institutional opinions and experiences in meeting the CNSS standards requirements
- Characterize CAEIAE and CNSS institutions' information assurance programs as to their size, longevity and importance within their respective departments

In meeting the goals of this survey, we expect to collect information that will be of value to the security education community. By documenting schools' experiences, we should then be able to evaluate the adequacy of the CNSS training standards for academic security programs. Survey results may indicate that a new standard might be needed, provide support for the existing standards as is or record suggestions for improving the standards. Gathering data on the CAEIAE and CNSS IACE computer security programs will provide a more complete picture of the scope and importance of security education within this group of institutions.

In this section we presented the background and motivation for our survey. Section II briefly introduces the CNSS training standards, their history and use. In Sections III and IV we present our survey design and the results from administering the survey. Section V discusses the survey data in relation to our stated goals. We conclude the paper and make recommendations for further study in Section VI.

II. CNSS Standards

As part of becoming a CAEIAE, schools must meet the requirements of IACE. The goal of this program is to insure compliance with national standards for information assurance education and training. To pass the IACE program, an institution must map its courses to the 4011 training standard for Information Systems Security Professionals and one other training standard 4012 - 4016 [3] (see Table 1).

Table 1. CNSS Training Standards

Standard Name	**Year**	**Description**
NSTISSI 4011	1994	Information Systems Security Professionals
CNSSI 4012	2004	Designated Approving Authority
NSTISSI 4013	2004	System Administrators in Information Systems Security
NSTISSI 4014	2004	Information Systems Security Officers (ISSO)
NSTISSI 4015	2000	System Certifiers
CNSSI 4016	2005	Risk Analysis

The stated purpose of the IACE program is to meet national standards for IA education and training. IACE is an assessment of the degree to which courseware from commercial, government and academic sources maps to the national standards. Thus, the IACE program's purpose is much broader than academic compliance, also extending to government and commercial training programs [3].

A. CNSS Standards History

The IACE program was established by the National Security Telecommunications and Information Security Systems Commission (NSTISSC) in 2000 in response to Presidential Decision Directive 63 (PDD 63) on critical infrastructure protection [3]. The NSTISSC, renamed the Committee on National Security Systems (CNSS), is responsible for setting policy for the security of federal government systems. PDD 63 documented a shortage and need for more information assurance professionals and called for the establishment of national training standards in information assurance [5].

III. Survey Design

In this section we discuss the process of designing and administering the survey to the CNSS certified institutions.

A. Survey Goals

As stated in the introduction, the main goals of the survey were to assess institutions' experiences in mapping their curricula to the CNSS standards and to collect background data on the security programs within the CNSS institutions in order to characterize the programs as to their size and importance within the schools' respective departments.

Other goals of the survey include:

- Determine the need for academic security standards
- Compare differences in computer security program characteristics between two- and four-year schools and universities with graduate programs

One of the survey questions asked respondents for their opinion as to the need for college-level security standards. In asking this question, we were seeking to determine if academic departments believe there should be specific standards that address college computer security curricula. Other questions targeted differences between the security programs of different types of schools. In other words, can security programs be grouped in relation to type of institution?

B. Sample Size and Survey Type

Most survey research is concerned with sampling a smaller group in order to extrapolate survey results to a larger population [6]. Thus, the size of the sample group is important for accurately capturing the information of interest [7]. Since the population we were surveying was fairly small, 112 schools, we sent the survey to the entire group of CNSS certified schools with the understanding that a typical survey response rate might be fairly low.

Our survey was to be self-administered by the person who performed most of the mapping to the CNSS standards. We chose to mail the surveys since electronic surveys are often ignored [8]. However, since several sites reported not receiving the survey, we re-sent these surveys via e-mail. We also sent e-mail reminders to the entire group in order to boost response rate.

Other design decisions included the use of open-ended (short answer) vs. closed-ended (select from a list) questions and the type of scale used to rank the responses. Since the questionnaire was to be self-administered, we structured the questions as mostly closed-ended to improve uniformity and simplicity of coding and analysis. We chose the Likert scale for the question response format:

1-Strongly Agree (SA)
2-Agree (A)
3-Undecided (U)
4-Disagree (D)
5-Strongly Disagree (SD)

One advantage of the Likert scale is it is easily converted to numeric scores for data analysis [7].

C. Survey Evaluation

Ideally, after developing the survey, it should be tested on a pilot group of respondents who are representative of the population to be surveyed [6]. However, because our survey goals were simple, *capture security program data plus record CNSS institution experiences aligning their courses to standards*, field testing the survey through the use of a pilot group was not practical. Instead, we had it reviewed by several computer security educators qualified to comment on the clarity and content of the questions. We also elicited feedback from individuals experienced in survey design. Based on their recommendations, the survey was modified to improve its understandability and internal consistency.

D. Survey Questions

Since our survey had two main goals: characterize academic security programs and investigate schools' mapping experiences, we divided the survey into two parts. The first part contained five background questions (Figure 1) and the second part twelve CNSS standards questions (Figure 2).

The background questions recorded the institution type, size of security program and status as a CAEIAE. The mapping questions assessed whether schools had found the mapping process straightforward, recorded their satisfaction with the CNSS standards and asked about the need for other standards or curriculum development materials.

1. Your school can be classified as:
   a. __ 2 year Community College
   b. __ 4 year College/ University
   c. __ University with Graduate Programs
   d. __ Other
2. How many academic departments teach courses in your Information Assurance (IA) curriculum?
   a. ___ 1
   b. ___ 2
   c. ___ 3-5
   d. ___ more than 5
3. How many additional academic departments have students who are taking classes from your IA curriculum?
   a. ___ 1
   b. ___ 2
   c. ___ 3-5
   d. ___ more than 5
4. With respect to the NSA Centers of Academic Excellence, your school is:
   a. ___ a current CAE
   b. ___ applying for CAE status in next 1-3 years
   c. ___ is not applying for CAE status in the next 1-3 years
   d. ___ unsure
5. How many full time/part time faculty are associated with your IA program?
   Full-time _____
   Part-time _____

Figure 1. Survey Background Questions

In processing the responses, we maintained anonymity by removing the respondents' identifying information. This was consistent with University of Idaho policy for human subject research[1] and did not affect the survey results

[1] Research that involves subject identification requires more stringent data handling and long-term guarantees for subject privacy.

1. The CNSS 4011 and other 40XX Training Standards provide excellent guidance for the non-research oriented college-level IA curriculum.
2. The CNSS 4011 and other 40XX Training Standards provide excellent guidance for the research oriented college-level IA curriculum.
3. The CNSS 4011 and other 40XX Training Standards have several components that do not map to college-level IA curriculum.
4. There are missing components in the CNSS 4011 and other 40XX Training Standards that should be included in a college level IA curriculum.
5. I am satisfied with the CNSS 4011 and 40XX Training Standards and do not feel the need for additional IA curriculum standards.
6. If there were an additional IA standard specifically designed for college level curriculum, I would not use it.
7. If there were a source where IA curriculum materials and resources relating to IA were publicly available to schools, I would use it.
8. If there were a source where IA curriculum materials and resources relating to IA were publicly available to schools, I would contribute material to it.
9. The mapping of CNSS 40XX Standards to our curriculum a straightforward process.
10. We did not use resources other than CNSS 40XX standards in developing our IA curriculum.
11. We did not consult with other faculty, government or industry professionals in creating our IA curriculum.
12. The IA program is not an area of importance within our department.

Figure 2. Curriculum Mapping Questions

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IV. Survey Results

The overall response rate for this survey was high at 50%: 56 of 112 surveys were returned[2]. For self-administered surveys, there is typically a lower response rate than either face-to-face or telephone interview formats [7].

A. Institution Characteristics

The first part of our data analysis[3] concerned the five background questions. Question 1 classified respondents by school type and produced the following distribution:

Other	4 %	2
2-Year School	14 %	7
4-Year School	16 %	8
University w/ Research	66 %	38

This breakdown shows that the majority of schools which responded to the survey have both undergraduate and graduate programs, which reflects the makeup of the CNSS school population where well over 60% constitute four-year schools with research programs [9].

For the next set of background questions we pooled responses from all the schools since we were not trying to distinguish the schools' security program by school type. Background Questions 2 and 3 address the number of departments involved in IA and are presented in Table 2.

Table 2. Departments Involved in IA

Background Questions	**1-2**	**3-5**	**> 5**
2. Academic departments that teach IA classes	27	24	4
3. Additional departments that teach IA classes	20	22	13

The data illustrate that the majority of schools have up to five academic departments participating in IA education.

Question 4 asked schools to indicate their status as a CAEIAE. The majority (37 of 55) are currently CAEIAEs with another 10 planning on becoming CAEIAEs within the next three years.

Questions 5a and 5b asked about the number of full-time and part-time faculty involved in IA. Responses ranged from a low of 0 for both full-time and part-time faculty to a high of 25 for full-time and 30 for part-time faculty. Mean numbers of faculty were 7 full-time and 4 part-time.

One question from the mapping section, Question 12, asked respondents to state the importance of computer security within their departments. The statement was phrased negatively and had the smallest range of all the survey questions with a mean of 4.7 out of 5, indicating strong disagreement with the statement that computer security is unimportant to their departments.

One trend that was noticed among the respondents was the number of years in IA versus the number of total years in academia. There was a large percentage of respondents, over 65%, that were experienced educators of more than 10 years but with relatively few years 3 to 5 teaching IA. This indicates that for many schools computer security is a relatively recent emphasis.

B. CNSS Mapping Experience

The questions reported in this section refer to the institutions' experience in mapping their curricula to the CNSS standards. The first two mapping questions address the suitability of the 4011 standards family for curriculum guidance at the undergraduate and graduate levels. Since the majority of responding schools have both undergraduate and graduate programs, we wanted to determine if these schools believed the standards were better suited to lower- or upper-level courses. Mapping

[2] One survey was returned only partially complete and so was excluded from analysis.
[3] All analysis of the survey data was done with the SAS Statistical software package [10].

Question 1 asked if the CNSS standards provided good guidance for undergraduate academic programs and Question 2 asked the same question for graduate programs (Figure 2). Responses showed little difference between the two questions with means of 2.2 and 2.9 leaning toward agreement with both statements (Table 3).

Table 3. Mapping Questions Means, Std. Dev., Range

Question	Mean	Std. Dev.	Range
Q1	2.2	1.3	1 - 5
Q2	2.9	1.4	1 - 5
Q3	2.2	1.2	1 - 5
Q4	2.6	1.0	1 - 5
Q5	3.0	1.3	1 - 5
Q6	3.5	.89	1 - 5
Q7	1.77	.77	1 - 3
Q8	1.79	.71	1 - 3
Q9	3.11	1.4	1 - 5
Q10	4.2	1.0	1 - 5
Q11	4.5	.69	2 - 5

The next four mapping questions asked respondents to evaluate the standards in more detail and gauge the need for additional standards. Questions 3 and 4 asked whether the standards had components that were either not mappable to college level curricula or missing from the standards. The mean responses to these questions were 2.2 for the unmappable components and 2.6 for the missing components, indicating general agreement that the CNSS standards have missing components and components that do not map to academic curricula. Question 5 asks respondents to agree or disagree with the statement that there is no need for other IA curriculum standards. Question 6 states that if there were other standards for academic curriculum development the respondent would not use them. Both means for these statements were higher than for previous questions with 3.0 and 3.5 respectively for Questions 5 and 6. Since the means for these questions indicated a mixed response, answers were counted to determine if respondents were undecided or truly agreed or disagreed with the statements. Counts indicated that there was no clear trend for Question 5 with a number of responses in all five categories. Question 6 showed nearly half agreed with not using other standards, with slightly fewer being undecided.

Table 4. Distribution of Responses for Q5, Q6 and Q9

Question	Responses				
	(SA) 1	(A) 2	(U) 3	(D) 4	(SD) 5
Q5	5	19	7	12	10
Q6	1	3	23	18	8
Q9	8	16	2	16	11

Questions 7 and 8 asked about the need for a curriculum repository and the willingness to contribute materials if one were established. Responses to both these questions averaged 1.7, indicating strong agreement. Question 9 asked if the overall mapping process proved straightforward. The mean was 3.1; a response distribution clarified that respondents were nearly equally divided with few being undecided. This question is discussed further in Section V.

The final two questions asked about other resources used by the institutions in developing their IA courses, stating that no resources in terms of people or materials were used outside of the CNSS Standards to develop curricula. Mean responses for both Questions 10 and 11 were high at 4.2 and 4.5, confirming that most schools did use outside resources in addition to the standards when creating their IA courses. Schools were asked to list the resources they used in developing their courses; these will be presented in Section V.

C. Differences between Institutions

One of the survey sub-goals as stated in Section III was to see if the course mapping experience varied according to the type of institution. Of the survey respondents, there were four types of institutions: two-year and four-year schools, universities with research programs, and "other training and commercial" institutions. Since our primary interest is with academic IA programs, we excluded the two surveys from the "other" category in this comparison.

The mapping questions that addressed the CNSS standards' suitability as academic standards included Questions 3, 4, 5 and 9. Prior to performing any statistical analysis of the data, histograms were constructed separately for Questions 3 and 4 (Figure 3) and Questions 5 and 9 (Figure 4). From these graphs it appears that responses from the two-year and four-year schools have greater similarity than with the institutions with research programs in the university category.

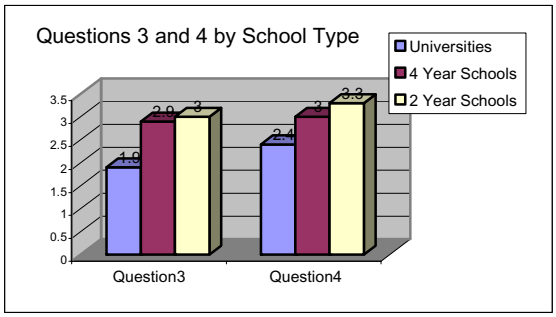

Figure 3. Distribution of Schools by Q3 and Q4

However, in order to determine true differences, the groups must be tested for significant differences in their responses to the above four questions.

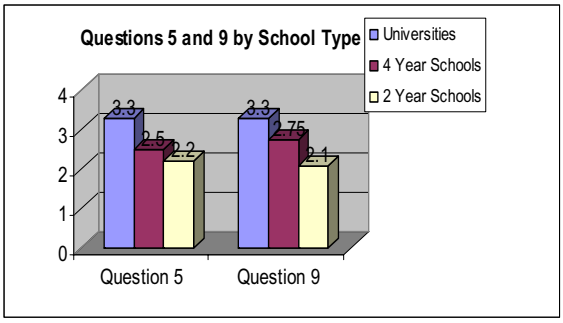

Figure 4. Distribution of Schools Q5 and Q9

Because the data are recorded as discrete values with a limited range of 1-5, they are regarded as ordinal data where the values are ordered but each increment does not strictly increase by a uniform amount. As such, ordinal data are not generally treated as normally distributed [11] since a normal distribution is based on continuous, real-valued data. Thus, statistical tests for differences between groups which depend on a normal distribution such as Analysis of Variance (ANOVA)[4] and *t*-tests could not be used. Instead, the Kruskal-Wallis test, which is considered the non-parametric[5] version of ANOVA, and the Wilcoxon test, the non-parametric version of the *t*-test, are used [12]. Our independent variable for each of the questions is the respondent's score and our dependent variable is the school type, 2-Year, 4-Year and University.

Results from calculating the Kruskal-Wallis test for Mapping Questions 3-5 and 9 are presented in Table 5.

Table 5. Kruskal-Wallis Test for Q3-Q5, Q9

Question	Chi-square	Pr > Chi-square
Q3	6.45	.0396
Q4	6.53	.0381
Q5	3.94	.1396
Q9	4.73	.0939

The Kruskal-Wallis test relies on a chi-square distribution and computes a chi-square value for the comparison between groups [12]. For the comparison of the three institution types, 2-Year, 4-Year and University programs, the tests show that the differences between groups are barely significant[6] for Questions 3 and 4, while Questions 5 and 6 show no significant difference. The last column, Pr > Chi-square, provides the probability that there is a value higher than the chi-square value in Column 2 [10]. For example, the probability that a value from the chi-square distribution exceeds the Q3 chi-square value 6.45 is about .04 (slightly significant).

In examining the differences between the three groups, there appeared to be more similarity between the two-year and four-year schools and greater differences between these two groups and the university schools with research programs. Consequently, the two- and four-year schools were grouped together and a two-group comparison was computed between this combined group and the original university schools. Results are presented in Table 6.

Table 6. Wilcoxon Rank Sums for Q3 - Q5, Q9

Question	Z Score	Pr > Z
Q3	2.53	.0144
Q4	2.48	.0165
Q5	-1.97	.0485
Q9	-2.04	.0409

Since this is now a two-group comparison, another test was used, the Wilcoxon Rank Sums test, the non-parametric version of an independent *t*-test [11]. The above table indicates that for all four questions, there is a significant difference in responses between research versus non-research schools.

V. Discussion

The relatively high response rate of 50% is higher than average for most self-administered surveys. The high return rate suggests some interest from the respondents in contributing to the survey outcome. From the responses to the background questions, most of the CNSS certified institutions believe that computer security is an important area for their department. However, the large disparity between most of the respondents' length of academic career and their involvement with the field of IA suggests that computer security is a newer area for many of these institutions.

In evaluating whether the survey met the goal of capturing respondents' experiences in mapping their curriculum to the CNSS standards, we need to examine the responses to the mapping questions. Overall, a clear majority of respondents felt that the standards did not provide good guidance for either undergraduate or graduate curricula, plus they had problems with

[4] ANOVA is typically used for testing significant differences when there is one independent variable and two or more levels of a dependent variable.
[5] Non-parametric statistics include tests that do not typically depend on known distributions with measurable parameters.
[6] Statistical significance is generally accepted as .05 or less for most purposes [11].

components from the standards that were either missing or did not map well to academic courses.

These results were reinforced by comments provided by the respondents. The following statements illustrate the most common criticism provided by survey participants:

> "The on-line form process is quite painful …"
>
> "Standards are so fragmented that it is hard to map specific courses … "
>
> "Very tedious with tiered questions, unclear in spots on whether course input should be from minimal set or every course that contained relevant topic points."
>
> "Training oriented … standards are too detailed resulting in outdated criteria in a short time … "

Components identified as missing from the standards include more recent IA topics such as forensics, risk management and wireless network security plus more classic topics such as secure system development, formal methods, non-interference and threat modeling, among others.

The questions on establishing a repository for curriculum materials and willingness to contribute materials demonstrated the desire for such a repository among the survey participants. In developing their IA courses, most schools used both outside sources and outside people. Among the most commonly mentioned resources were textbooks, other schools, faculty expertise, NIST publications, Web sources, research, commercial training standards and IEEE standards. The outside people who contributed knowledge to course development included advisory boards, FBI, other faculty, NSA representatives, CIOs and CTOs of companies, DOD and NIST personnel.

Several survey questions generated a broad distribution of answers. These questions concerned the need and use of additional curriculum standards. Question 5, which asked about the need for additional standards, had a very split response with about half the respondents in favor and half indicating that there was no need. Question 6, asking if people would use a standard specifically designed for college curricula, generated many undecided responses. From these questions it is unclear if there is a strong desire for another curriculum standard.

Analyzing the survey comments volunteered by respondents provided further support that changes would be beneficial in the CNSS standards. Many comments suggested that the CNSS standards are out-of-date and do not cover many of the current areas of research and practice. Another common comment was the high level of detail in the standards plus the fragmented nature of the topics covered. Multiple respondents mentioned that they had to include several courses in order to cover all the topics in a single standard.

Other comments dealt with the training-oriented nature of these standards. Respondents often felt that the standards' focus on training dealing with highly specific items that must be taught does not belong in college-level curricula.

Comments were not entirely negative; many respondents said the CNSS certification program has been beneficial to their schools and they are able to use the IA certificates as a marketing tool. One school mentioned that they had placed 100's of students in the IA field because of their IA program and CNSS certification.

VI. Conclusion and Future Work

Our purpose in querying institutions that have sought CNSS certification for their IA program is to insure that standards used for curriculum development meet the needs of the academic community and fulfill their intended purpose, to provide quality education in IA. Standards are critical in this process since they determine what is taught and the targeted level of instruction.

In answering questions about the suitability of the CNSS standards for academic programs, we found that respondents' indicated a need for some improvement to the standards. Respondents' answers support prior complaints that the standards emphasize training and are not adequate as guidance for academic IA programs. Responses did not clearly indicate a desire for additional standards, but comments did clearly support that at least an update and re-organization of the CNSS standards is warranted.

By distilling the feedback from the schools into several recommendations, we hope to provide several possible ways to move forward and promote discussion within the security education community. These recommendations are not mutually exclusive and include:

1. Re-organize the CNSS standards around academic curricula instead of job function.
2. Update and expand the standards to include current IA topics that are now missing.
3. Replace one or more standard with a standard more suitable for academic education. For example, the Common Body of Knowledge for Software Assurance [13] is one evolving standard which could serve as a substitute.
4. Form an academic curriculum committee with industry, government and academic members to oversee the standards required for IA education.

A. Future Work

This survey was specifically designed to obtain information from a targeted population, the CNSS certified institutions. It would be interesting to survey schools outside of this group so that a more complete picture could be obtained on the status of IA education in the wider population of colleges that teach computer science or information security. We hypothesize that smaller schools with limited resources are less likely to teach courses in computer security unless they already have faculty with a security background. A survey of these schools would support or negate that hypothesis and is planned for a future date.

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