



KU Alignment with PUPR's Program of Study

Author: Rose A. Luna Rivera

Advisor: Alfredo Cruz, Ph.D.

Master in Computer Science

Graduate Project EXPO, October 2025

Abstract

Academic institutions can become designated as a Center of Academic Excellence (CAE). This demonstrates that the institution meets the standards for cybersecurity curriculum. As part of the requirements, the academic institution must align the degree's courses with a certain number of Knowledge Units (KUs). This project mapped and aligned PUPR's Master of Science in Computer Science with these designation requirements. The process was carried out using the program's courses, their syllabuses, textbooks, and the KUs' learning outcomes and topics. This project aimed to align the educational program with the two categories: technical core and non-technical core.

Introduction

When academic institutions apply for the National Center of Academic Excellence in Cyber Defense designation (CAE-CD), they must choose from three designations [1][2]. The application has two separate processes: the Program of Study (PoS) validation and then the CAE-CD Designation [3]. As part of the PoS validation, the academic institution must provide a Knowledge Unit (KU) alignment. Depending on the nature of the PoS, the courses must cover a set of specific KUs. For master's degree programs, the PoS must align to three Foundational KUs, five Core KUs, seven Optional KUs, and an additional seven (7) KUs for thesis or its equivalent. Regarding the Core KUs, the academic institution must choose between the Technical Core and the Non-Technical Core.

The Polytechnic University of Puerto Rico (PUPR) offers a Master of Science in Computer Science [4]. Since 2009, PUPR has been recognized as a Center of Academic Excellence in Information Assurance Education (CAE/IAE) and has successfully received re-designation. [5].

Background

As cyber threats grow, academic institutions must do their part in shaping the future cybersecurity professionals. Smith highlighted the importance of higher education in offering cybersecurity courses and degrees [6].

Capitol Technology University also emphasizes the importance of incorporating cybersecurity into higher education [7]. They recommend that universities seek designations such as NCAE-C, as this will demonstrate that their program is well-equipped to prepare students for the cybersecurity workforce.

Osman explains the role of higher education in preparing students for the cybersecurity workforce [8]. As the cybersecurity industry is expected to continue growing, Osman emphasizes the need for universities to quickly adapt their curricula by, for example, following industry standards such as the National Initiative for Cybersecurity Education (NICE) Workforce Framework and the Department of Defense Cyber Workforce Framework (DCWF). The NICE Framework is a resource developed by the Department of Homeland Security (DHS) and the National Institute of Standards and Technology (NIST) [9] [10]. The DCWF leverages the NICE Workforce Framework. Similar to this framework, DCWF outlines the work performed by various cybersecurity roles [11].

The CAE-CD KUs are tailored to provide students with the necessary knowledge and skills established in both frameworks, the NICE Workforce Framework and the DCWF [12].

Problem

Every year, the CAE-CD requirements change by adding and removing KU outcomes, topics, and even entire KUs. The latest and current requirements are valid through December 2025. This project compares and aligns the current requirements with PUPR's PoS. Since the academic institution must choose between the Technical and Non-Technical categories for the CAE-CD designation, this project challenges this approach and attempts to align the PoS with both categories.

Methodology

The KU mapping serves as the foundation of the entire project. The KU mapping involves comparing each KU learning outcome and topic with the course objectives and topics. The process is as follows. Starting with the first KU, the syllabus of the first course is reviewed, and the listed objectives and course outline, along with the KU learning outcomes and topics, are compared. Whenever both coincide, it is marked as mapped. Upon finishing the syllabus, the search for learning outcomes and topics is continued by reviewing the course's book(s). After completing this check-up with the first course, the same process repeats with the next course. Once all courses and books are completed, the entire process is repeated with the next KU until all 73 KUs are mapped.

The result of this process is how the courses map to each KU. However, this does not represent the actual KU alignment. The reason for this is that the course must map to most of the KUs' topics so it can then be considered as aligned. It should be mapped with at least 75% of the outcomes and topics.

Table 1: Foundational KU Mapping

	Foundational		
	CSF	CSP	ISC
CECS 6005	X	X	X
CECS 7230		X	
CECS 7570	X	X	
CECS 6015			X

Table 2: Technical Core KU Mapping

	Technical Core				
	BCY	BNW	BSP	NDF	OSC
CECS 6005		X			
CECS 6605			X		
CECS 7230	X			X	
CECS 7570	X	X			X
CECS 6015		X			

Table 3: Non-Technical Core KU Mapping

	Non-Technical Core				
	CTH	CPM	PLE	SPM	SRA
CECS 6005	X	X			X
CECS 6230		X			
CECS 7570	X	X	X		X
CECS 6015		X		X	X

Table 4: Optional KU Mapping

	Optional										
	ALG	CSE	DST	DVF	DFS	HOF	ITC	MEF	NWF	PRI	
CECS 6010	X		X								
CECS 6030							X				
CECS 7235				X	X	X		X	X		
CECS 7237			X	X	X			X	X		
CECS 6045		X									X
CECS 6046									X		

Results and Discussion

Only those courses that map to at least 75% of the KU's outcomes and topics are considered properly aligned with the KU. Therefore, of the 73 KUs, 47 are properly aligned, 6 are unmapped, and 20 are partially aligned.

The alignment of the courses with the KUs is presented in the different tables. Table 1 shows the three Foundational KUs, along with the four aligned courses. The alignment of the five Technical Core KUs is shown in Table 2. Five courses are aligned to these KUs. As for the five Non-Technical KUs, only four courses are aligned to these KUs. The alignment is depicted in Table 3. Table 4 shows the six courses that were aligned to ten Optional KUs. For the CAE-CD designation, Master's degree programs may include a Thesis or equivalent. PUPR's PoS offers a Graduate project course, CECS 7950. This course aligns with the seven (7) additional KUs dedicated to a Graduate thesis, dissertation, or equivalent. This is seen in Table 5.

The courses best suited for the CAE-CD designation are organized into two tables. Table 6 shows the Master Non-Technical CAE-CD mapping, and Table 7 shows the Master Technical CAE-CD mapping. With a total of 14 courses, PUPR's PoS offers a wide variety of topics. Thus, it achieves an extensive and varied alignment of KUs. Despite the selection of courses for the final alignment in this project, it is still possible to continue mixing and matching with different courses and Optional KUs. This results in numerous possibilities for the final alignment, each with different reasons behind it.

Table 5: Thesis and/or Institutional Equivalent Mapping

	Additional or Graduate Thesis/Dissertation/Equivalent						
	7 KUs for Graduate Project Course						
CECS 7950	X	X	X	X	X	X	X

Table 6: Master Non-Technical CAE-CD Alignment

	Master Non-Technical CAE-CD							
	CECS 6005	CECS 6010	CECS 6030	CECS 7235	CECS 7570	CECS 6015	CECS 6045	CECS 7950
CSF	X				X			
CSP	X				X			
ISC	X					X		
CTH	X				X			
CPM	X				X	X		
PLE					X			
SPM						X		
SRA	X				X	X		
ALG		X						
CSE	X						X	
DST		X						
DFS				X				
ITC			X					
MEF				X				
PRI							X	
7 KUs for Project Course								X
								X
								X
								X
								X
								X
								X

Table 7: Master Technical CAE-CD Alignment

	Master Technical CAE-CD									
	CECS 6005	CECS 6010	CECS 6030	CECS 7235	CECS 6605	CECS 7230	CECS 7570	CECS 6045	CECS 7950	
CSF	X						X			
CSP	X						X			
ISC	X									
BCY						X	X			
BNW	X						X			
BSP					X					
NDF						X				
OSC							X			
ALG		X								
CSE	X							X		
DST		X								
DFS				X						
ITC			X							
MEF				X						
PRI								X		
7 KUs for Project Course										X
										X
										X
										X
										X
										X
										X

Conclusions

The goal of this project was to align the courses of PUPR's Master's in Computer Science with the KUs that are part of the CAE-CD designation requirements. The results of this project demonstrate the preparation of PUPR's PoS. The Non-Technical CAE-CD supports and demonstrates the institution's current designation. Meanwhile, the Technical CAE-CD confirms that PUPR is also qualified to receive this designation.

This project emphasizes the importance of the CAE-CD designation. It serves as evidence that the institution is well-equipped and capable of preparing students competent for the cyber workforce. Students graduating from these institutions are talented, skilled, and proficient.

Future Work

Since the designation requirements are periodically changing, it would be interesting to see how these requirements change in January 2026. Future project would involve finding out if there are new KUs to which any course may be aligned. With the new designation requirements, an even more optimal final alignment could be achieved.

A future project could include a skills gap analysis of PUPR's PoS alumni. To complete this, a questionnaire would be prepared and sent to the alumni, asking about their skills and other relevant information. These results would be compared with the course objectives of the PoS and the DCWF and NICE frameworks. The result of this will give an even deeper insight into the quality of PUPR's PoS.

Acknowledgements

I sincerely thank my advisor, Dr. Alfredo Cruz, for his exceptional guidance throughout this project. I would also like to extend my thanks to the Graduate School staff.

References

- [1] Defense Information Systems Agency (DISA), "National Centers of Academic Excellence in Cybersecurity (NCAE-C)," [Online]. Available: <https://www.cyber.mil/ncae-c/>.
- [2] National Security Agency, "National Centers of Academic Excellence in Cybersecurity," [Online]. Available: <https://www.nsa.gov/Academics/Centers-of-Academic-Excellence/>.
- [3] Application Process and Adjudication Rubric (APAR) and Cyber Defense Working Group (CDWG), "National Centers of Academic Excellence in Cybersecurity NCAE-C 2024 Designation Requirements and Application Process For CAE-Cyber Defense (CAE-CD)," July 2024. [Online]. Available: https://dl.dod.cyber.mil/wp-content/uploads/cae/pdf/unclass-cae-cd_designation_requirements.pdf.
- [4] Polytechnic University of Puerto Rico, "Master of Science in Computer Science with a specialization in Cybersecurity," [Online]. Available: <https://pupr.edu/master-computer-science/>.
- [5] Polytechnic University of Puerto Rico, "Information Assurance and Security," [Online]. Available: <https://pupr.edu/information-assurance-and-security/>.
- [6] M. Smith, "Cyber security: How higher ed aims to meet the rising demand," 26 June 2023. [Online]. Available: <https://www.apporto.com/cyber-security-how-higher-ed-aim-to-meet-the-rising-demand>.
- [7] Capitol Technology University, "The Importance of Higher Education in Cybersecurity Studies," 6 June 2024. [Online]. Available: <https://www.captechu.edu/blog/importance-of-higher-education-cybersecurity-studies>.
- [8] T. M. Roydean Osman, "The Role of Higher Education in Building a Cyber-Resilient Workforce," 15 July 2025. [Online]. Available: <https://cybersecurityasia.net/building-cyber-resilient-workforce/>.
- [9] NIST, "NICE Framework History," 10 March 2025. [Online]. Available: <https://www.nist.gov/itl/applied-cybersecurity/nice/nice-framework-resource-center/about/nice-framework-history>.
- [10] NICCS, "NICE Workforce Framework for Cybersecurity (NICE Framework)," 28 August 2025. [Online]. Available: <https://niccs.cisa.gov/tools/nice-framework>.
- [11] Chief Information Officer, "Framework," [Online]. Available: <https://dodcio.defense.gov/Cyber-Workforce/DCWF/>.
- [12] A. Becker et al., "National Centers of Academic Excellence in Cybersecurity (NCAE-C) - Cyber Defense (CAE-CD) Knowledge Units," 2024. [Online]. Available: https://dl.dod.cyber.mil/wp-content/uploads/cae/pdf/unclass-cae-cd_ku.pdf.