July 2021

China's CyberAI Talent Pipeline

CSET Policy Brief

CSET
CENTER *for* SECURITY *and*
EMERGING TECHNOLOGY

AUTHOR

Dakota Cary

Executive Summary

China launched a government program to certify World-Class Cybersecurity Schools (WCCS; 一流网络安全学院)[1] in 2017. The Ministry of Education and Cyberspace Administration of China (CAC) have since awarded 11 universities the WCCS designation. Seven U.S. federal agencies, led by the Department of Homeland Security and the National Cryptographic School at the National Security Agency, similarly certify qualifying U.S. universities as Centers of Academic Excellence (CAE) in the areas of cyber defense, cyber research, and cyber operations.[2] Receiving a CAE, or WCCS, certification allows a university to promote its program as a rigorous course of study. Students from these institutions can quickly receive recognition on a job application for obtaining an excellent education in cybersecurity. Both the U.S.-CAE and China-WCCS programs set standards of excellence for cybersecurity education and aim to bolster the talent pool for each nation's respective cybersecurity sector.

China's WCCSs offer more courses in artificial intelligence/machine learning (AI/ML) in their cybersecurity programs than do the U.S. CAE-Cyber Operations degrees. Eight of China's 11 WCCS universities integrate classes on AI and ML into their cybersecurity degree programs; only one of the 20 U.S. universities certified in cyber operations offers an optional class on machine learning. Over time, China will gradually produce a significant cohort of graduates with both cybersecurity and AI/ML skills. Such widespread knowledge of both skills may increase innovation for, and speed adoption of, AI-enabled cybersecurity tools. By contrast, the U.S. CAEs do not develop valuable ML skills as part of the talent pipeline; the number of graduates with both cybersecurity and AI skills would increase significantly if the U.S. were to add an AI/ML course option or requirement for CAE degree programs.

This difference in competencies for cybersecurity professionals, typified by the differences in curriculum examined here, may grant China a growing advantage over the United States as both nations try to adopt AI-enabled cybersecurity tools or securely deploy AI-

enabled systems. In the United States, the well-developed cybersecurity talent pipeline can quickly adopt measures to remediate differences between these two curricula. The seven U.S. agencies tasked with overseeing the CAE program should monitor the progress of [13 National Science Foundation awards](#) that are testing new class structures that teach both AI and cybersecurity and consider adding new AI/ML knowledge units.

Introduction

Every nation aiming to remain competitive in its security services must nurture and develop a highly qualified cohort of potential employees. The task for agencies is to sift through this talent pool and ensure the most competitive applicants are offered employment. Seven federal agencies, led by the National Cryptographic School at the National Security Agency (NSA)[3], set the standard for excellence in the cybersecurity talent pool by offering voluntary CAE certifications for computer science degree programs. CAE-certified programs are not a pipeline into these agencies, nor are graduates treated preferentially in the application process. However, the university's certification does allow graduates to quickly communicate their skills to a potential employer, including the U.S. government.

China has followed suit in launching its own certification regime. China's 2016 National Cybersecurity Strategy outlined the standardization of cybersecurity degree programs as a critical component of improving the talent pipeline.[4] The strategy defines nine strategic tasks (战略任务), including "Solidifying the Cybersecurity Base," which sets out specific priorities for the standardization of the cybersecurity talent pipeline. These efforts culminated in a program under the 2017 "world-class universities and world-class curricula" (世界一流大学和一流学科) initiative, which aims to increase the number of globally-ranked Chinese universities. In August 2017, the Ministry of Education and the Central Cyberspace Administration of China (CAC) released a joint declaration codifying the priorities of the National Cybersecurity Strategy and creating standards for World-Class Cybersecurity Schools (WCCS; 一流网络安全学院)—the CAC quickly certified

seven universities as WCCSs that year.[5] As with the U.S. CAE certification, universities can voluntarily apply to receive the WCCS certification, which carries prestige but does not apparently confer other benefits at this time. The CAC certified four more universities in 2019, bringing the current total to 11.[6]

China's civilian and military intelligence services quickly lauded the program after its launch for its impact on the talent pipeline. In 2018, the Ministry of State Security 13th Bureau, which supports government cybersecurity and oversees some of the MSS's cyber operations, cited the WCCS certification program as evidence of the improving cybersecurity talent pipeline.[7] Similarly, researchers from the PLA Strategic Support Force Information Engineering University, itself a recipient of China's "world class cybersecurity school" designation, identified the certification program as critical to improving the cybersecurity talent pool. The PLA authors commended the program's focus on standardizing educational materials, hiring and maintaining faculty with hands-on experience, and encouraging applied learning through internships and competitions.[8] Two of the 11 universities, the University of Science and Technology of China and Shanghai Jiaotong University, signed a pact with the PLA SSF in 2017 committing to support the service's talent pipeline.[9] Both military and civilian intelligence services will benefit from the skilled applicant pool graduating from WCCS institutions.

Findings

China has taken the certification model used by other countries and expanded their course offerings. The 11 WCCS programs offer more courses on AI and machine learning than do the 20 U.S. CAE-Cyber Operations[10] certified degree programs. Eight of the 11 WCCS institutions offer such classes in their cybersecurity degree programs (code: 0839); only one of the 20 U.S. institutions offers a comparable course, and it is optional. In the United States, the National Cryptographic School publishes the criteria for both the CAE Cyber Operations and CAE Cyber Defense certifications— neither of which requires courses related to AI/ML.[11] Though China does not publish its criteria for WCCS certification, the offering of

AI classes by some, but not all, institutions suggests such courses are optional.

A full accounting of the Chinese institution's relevant course offerings and faculty is located in Appendix A. For a full listing of U.S. universities, see Appendix B.

Institution's Name in English	Institution's Name in Chinese	Cybersecurity Courses Include One AI/ML Class?
Xidian University	西安电子科技大学	Yes[12]
Wuhan University	武汉大学	Yes[13]
Beijing University of Aeronautics and Astronautics (Beihang University)	北京航空航天大学	Yes[14]
University of Science and Technology of China	中国科学技术大学	Yes[15]
PLA Strategic Support Force Information Engineering University	中国人民解放军战略支援部队信息工程大学	Inaccessible
Huazhong University of Science and Technology	华中科技大学	Inaccessible
Beijing University of Posts and Telecommunications	北京邮电大学	Yes[16]
Shandong University	山东大学	No[17]
Sichuan University	四川大学	Yes[18]
Southeast University	东南大学	Yes[19]
Shanghai Jiao Tong University	上海交通大学	Yes[20]

Analysis

China's strategic policy documents for AI development encourage the integration of AI/ML and cybersecurity. Universities that choose to integrate the two curricula are aligning themselves with China's strategic ambitions—something to be expected from any nation's top universities. The 2017 *New Generation Artificial Intelligence Development Plan* states that China must "strengthen AI cybersecurity technology research and development."[21] Another plan released the following year, the 2018 to 2020 *Internet +"*

Artificial Intelligence Three-Year Action Plan, identifies the need to apply AI to cybersecurity solutions.[22] Both strategic documents make clear the CCP's interest in melding the two technologies. China's WCCS institutions are on the front line of producing future employees capable of producing and deploying AI/ML-based cybersecurity tools.

It is difficult to assess the overall quality of AI and cybersecurity classes at various WCCS-recipient institutions. Times Higher Education, publisher of the *World University Rankings*, named the University of Science and Technology of China as the highest-ranked WCCS at 87th in 2021.[23] But such rankings are likely a poor conduit for understanding the quality of WCCS degrees, let alone specific courses. Wuhan University and Huazhong University of Science and Technology are joining forces to create the National Cybersecurity School at China's National Cybersecurity Center—both ranked between 301st to 350th.[24] Another low-ranked WCCS recipient, Southeast University ranked between 500th to 600th, received funding to improve China's information warfare capabilities and hosted a hacking competition tied to an APT hacking team.[25] China's universities produce graduates capable of attacking and defending networks, regardless of how international firms or assessments rank the institutions. While difficult to assess the quality of these curricula, the addition of AI/ML coursework is likely to reap benefits over the long-term and contribute to a deepening of the overall talent pool.

China will gradually bolster its institutional knowledge of cybersecurity and AI/ML with each successive class of WCCS graduates. In contrast, the U.S. government has not effectively accessed the full potential of its cyber talent pipeline. The number of graduates with both cybersecurity and AI skills would increase significantly if the United States were to add an AI/ML course option or requirement to CAE certification criteria. Under the current U.S. system, cyber/AI talent will likely be highly concentrated in pockets of expertise. Under China's system, cyber/AI talent is likely to be more diffuse. This difference between talent pipelines may, overtime, give the CCP an advantage over U.S. agencies in adopting AI-enabled cybersecurity tools or securely deploying AI-enabled systems. The nature of any such

advantage, should it emerge, will depend on much more than a standardized curriculum—but, at a minimum, a broader institutional understanding of both AI and cybersecurity will not disadvantage China's cyber capabilities. President Xi's oft-referenced quote on cybersecurity is that "Competition in cyberspace is, ultimately, a competition for talent" (网络空间的竞争, 归根结底是人才竞争).[26]

Recommendation

In April 2020, the National Science Foundation (NSF) solicited proposals for research exploring how to integrate the study of AI into cybersecurity degrees.[27] The request for research proposals directly responded to the 2019 Federal Cybersecurity Research and Development Strategic Plan, which identified AI as one of its priority areas of research.[28] Of the 24 recipients of the corresponding NSF grant, 13 different research projects are conducting pilot programs that aim to teach undergraduate and graduate students both AI and cybersecurity skills.[29] The results of these studies, which will conclude in September 2022, should be used to create new CAE certification requirements.

The seven U.S. agencies tasked with overseeing the U.S.-CAE program should monitor the progress of 13 NSF awards and, should the research prove successful, prepare to quickly implement the resulting education programs on cybersecurity and AI.

- The seven administering agencies should add new knowledge units (KUs) regarding AI/ML to CAE certification criteria following the conclusion of these research grants.

- The U.S.-CAE recipients should correspondingly implement the best practices determined by these 13 research projects, in addition to the content outlined by new KUs.

Conclusion

Most of China's WCCS programs already offer courses on AI and cybersecurity, though the structure and content of these courses vary widely (see Appendix A). Still, China will graduate cybersecurity practitioners with both sets of skills from these programs, further bolstering the cyber/AI nexus that boosts private-sector innovation and government talent acquisition. Over the long run, China's WCCS talent pipeline will lead to a more widespread understanding of AI's impact on cybersecurity than in the United States under our current CAE system. But the United States has taken important first steps towards creating and implementing a more widespread and better designed system than what currently exists in China.

U.S. policymakers, specifically the seven agencies involved in designing the three CAE curricula (Cyber Defense, Cyber Operations, and Cyber Research), have the opportunity to quickly scale-up the U.S. cyber/AI talent pipeline. By monitoring the on-going research of 13 NSF grant recipients and revisiting the knowledge units required to receive each CAE certification, the United States can rapidly respond to research successes and encourage current CAE certification-holding institutions to begin hiring the necessary talent to incorporate such classes into their programs. Although the process of implementing these curriculum changes will take time, China's short lead period and haphazard program structure do not offer it a significant advantage if the United States acts promptly. The decades-long investment by the United States in creating a formal process for standardizing cybersecurity education has undoubtedly paid-off. The time to update our standards of excellence in cybersecurity education is now.

Author

Dakota Cary is a research analyst at CSET, where he works on the CyberAI project.

Acknowledgments

Thanks to John Bansemer, Kady Arthur, Dan Blumenthal, Linda Zhang, Drew Lohn, Diana Gehlhaus, Dahlia Peterson, Kayla Goode, Emily Weinstein, Ryan Fedasiuk, and Ngor Luong.
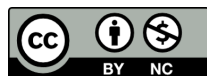
Appendix A: By Institution Analysis

Xidian University (西安电子科技大学)

The CAC awarded Xidian University status as a World-Class Cybersecurity School in 2017.[30] The courses offered by Xidian for undergraduate students include optional courses under the Applied Security concentration in machine learning, and AI & big data management.[31]

Wuhan University (武汉大学)

The CAC awarded Wuhan University status as a World-Class Cybersecurity School in 2017.[32] Course work for Wuhan University is inaccessible, but its content can be gleaned from accessible web pages for university professors. Associate professor Zhao Lei (赵磊) instructs courses on vulnerability analysis (漏洞分析) and AI Security & Applied Security (AI安全及应用). Another associate professor, Shen Zhidong (沈志东), teaches a class on AI and Security Analysis (人工智能与安全分析). Listed among visiting scholars to the institution, Dr. Shen Shiqi (沈诗琦）of Singapore is reported to have presented on using machine learning for computer program analysis—a process which helps developers find and fix (or exploit) weaknesses in a given program.[33]

Wuhan University is partnered with Huazhong University of Science and Technology to build the National Cybersecurity Center's National Cybersecurity School.[34]

Beijing University of Aeronautics and Astronautics (北京航空航天大学)

The CAC awarded Beijing University of Aeronautics and Astronautics (Beihang University; BUAA) status as a World-Class Cybersecurity School in 2017—the only of the Seven Sons of National Defense universities to achieve the designation.[35] BUAA's doctoral candidates in the cybersecurity college were offered only one class on AI and cybersecurity—entitled AI Technology and its Security Application (人工智能技术及其安全应用).[36] Undergraduate students are apparently unable to take any classes on this topic. BUAA offered more courses on quantum cryptography and

advanced information assurance technologies than on AI—not surprising given the University's work with the country's space program.

University of Science and Technology of China (中国科学技术大学)

The CAC awarded University of Science and Technology of China (USTC) status as a World-Class Cybersecurity School in 2017.[37] USTC academic courses and research direction rest firmly at the intersection of cybersecurity, AI/ML, and quantum computing. In one of four possible research directions for graduate students, the university notes that "the combination of quantum computing with machine learning and artificial intelligence will (among other things) change network security situational awareness and methods of computer network defense" (量子计算与机器学习和人工智能的结合也将改变网络安全态势感知和网络防御的模式).[38] Despite the WCCS not offering any classes at the intersection of AI and cybersecurity, students can take classes in both as separate topics.[39] Though they might not yet teach such classes, professors at USTC are conducting research into cybersecurity and AI related topics. Professor Dai Lirong (戴礼荣) is conducting research on attacks and defenses in deep learning systems (深度学习系统的攻击与防御). Two other professors, Wang Jie (王杰) and Zhu Ming (朱明), are both conducting researching into the application of AI/ML for network security (机器学习技术在网络空间安全中的应用).[40] Additionally, more than 10 full-time professors are working on research related to quantum cryptography, quantum computing, and quantum information sciences.

PLA Strategic Support Force Information Engineering University (中国人民解放军战略支援部队信息工程大学)

The CAC awarded Strategic Support Force Information Engineering University status as a World-Class Cybersecurity School in 2017.[41] The university's webpage is largely inaccessible—information regarding course structure or professors' research topics could not be found.

Huazhong University of Science and Technology (华中科技大学)

The CAC awarded Huazhong University of Science and Technology (HUST) status as a World-Class Cybersecurity School in 2019.[42] HUST cybersecurity college's course catalogue is inaccessible, though a description of the program on the website describes classes typical of a cybersecurity program.[43] HUST is one of two universities involved with China's National Cybersecurity Center.

Huazhong University of Science and Technology is partnered with Wuhan University to build the National Cybersecurity Center's National Cybersecurity School.[44]

Beijing University of Posts and Telecommunications (北京邮电大学)

The CAC awarded Beijing University of Posts and Telecommunications (BUPT) status as a World-Class Cybersecurity School in 2019.[45] BUPT graduate students in the cybersecurity school can select to conduct research in one of 10 concentrations. Three of those 10 concentrations overlap AI and traditional cybersecurity: 1) network security, content security, and machine learning (网络安全、内容安全、机器学习); 2) network attack and defense, mobile phone security, AI, and social engineering (网络攻防、手机安全、人工智能、社会工程学); 3) network attack and defense, vulnerability discovery, AI and security analysis (网络攻防、漏洞挖掘、人工智能与安全分析).[46] Doctoral candidates can choose from many similar concentrations—including research on intelligent vulnerability discovery (智能漏洞挖掘), quantum cryptography, and information assurance.[47]

Shandong University (山东大学)

The CAC awarded Shandong University status as a World-Class Cybersecurity School in 2019.[48] Shandong University offers one class on machine learning to undergraduate and graduate students.[49]

Sichuan University (四川大学)

The CAC awarded Sichuan University status as a World-Class Cybersecurity School in 2017.[50] Sichuan University offers at least one class on AI or machine learning to its cybersecurity program.[51]

Southeast University (东南大学)

The CAC awarded Southeast University status as a World-Class Cybersecurity School in 2017.[52] Southeast University offers one optional research class on AI for undergraduates, graduate students, and doctoral candidates.[53]

Shanghai Jiao Tong University (上海交通大学)

The CAC awarded Shanghai Jiao Tong University status as a World-Class Cybersecurity School in 2019.[54] Shanghai Jiao Tong University offers one course on AI for undergraduate, graduate, and doctoral candidates.[55]

Appendix B: U.S. CAE Cyber Operations Schools

U.S. Center for Academic Excellence in Cyber Operations	Degree Courses Include One AI/ML Class?
Carnegie Mellon University (Pennsylvania) 2019-2024 (Fundamental) M.S. in Information Security, Specialization in Cyber Operation	No[56]
Cedarville University (Ohio) 2018-2023 (Fundamental) B.S. in Computer Science with a Specialization in Cyber Operations	No[57]
Dakota State University (South Dakota) 2012-2022 (Undergraduate) B.S. in Cyber Operations	No[58]
Mississippi State University (Mississippi) 2013-2020 (Graduate) M.S. in Computer Science with Cyber Operations Certificate	No[59]
Naval Postgraduate School (California) 2012-2020 (Graduate) M.S. in Computer Science, Cyber Systems and Operations Specialization	No[60]
Northeastern University (Massachusetts) 2012-2022 (Undergraduate) B.S. in Computer Science, Concentration in Cyber Operations/B.S. in Cyber Security, Concentration in Cyber Operations	Yes[61]
New York University Tandon School of Engineering (New York) 2014-2020 (Graduate) M.S. in Cybersecurity, Cyber Operations Specialization	No[62]
Old Dominion University (Virginia) 2019-2024 (Fundamental) B.S. in Interdisciplinary Studies, Cyber Operations Major	No[63]
Texas A&M University (Texas) 2017-2022 (Undergraduate) B.S. in Computer Science, Minor in Cybersecurity / B.S. in Computer Engineering, Minor in Cybersecurity	No[64]
Towson University (Maryland) 2014-2024 (Undergraduate) B.S. in Computer Science with a Track in Computer Security	No[65]
United States Air Force Academy (Colorado) 2016-2021 (Undergraduate)	No[66]
University of Arizona (Arizona) 2018-2023 (Fundamental) B.S. in Cyber Operations	No[67]
University of Cincinnati (Ohio) 2014-2024 (Graduate) M.S. of Computer Science / M.S. of Computer Engineering, Graduate Certificate of Proficiency in Cyber Operations	No[68]

University of Nebraska Omaha (Nebraska) 2017-2022 (Undergraduate) B.S. in Cybersecurity, Special Track in Cyber Operations	No[69]
University of New Haven (Connecticut) 2019-2024 (Fundamental) B.S. in Computer Science, Cyber Operations/ B.S. in Cybersecurity and Networks, Cyber Operations	No[70]
University of Texas at Dallas (Texas) 2015-2020 (Graduate) M.S. or Ph.D. in Computer Science with a Certification in Cyber Operations	No[71]
University of Texas at El Paso (Texas) 2016-2021 (Undergraduate) B.S. in Computer Science Secure Cyber-Systems (SCS) Track	No[72]
University of Texas at San Antonio (Texas) 2018-2023 (Fundamental) B.S. in Computer Science, Cyber Operations Track	No[73]
University of Tulsa (Oklahoma) 2012-2020 (Graduate) M.S./Ph.D. in Computer Science, Specialization in Cyber Operations (a.k.a. Tulsa Cyber Corps Program)	No[74]
Virginia Polytechnic Institute and State University (Virginia) 2017-2022 (Undergraduate) B.S. in Computer Engineering, Minor in Cybersecurity, Certificate in Cyber Operations	No[75]

Endnotes

[1] The PRC government launched its "world-class universities and world-class curricula" (世界一流大学和一流学科) initiative, abbreviated "double world-class" ("双一流"), in 2017 with the aim of increasing the number of Chinese universities that rank among the world's best. In August 2017, the Cyberspace Administration of China released its "Notice on the Publication of Management Methods for the Demonstration Project for Building World-Class," which established World-Class Cybersecurity Colleges as a subset of the "double world-class" initiative. See "Original CSET translation of 'Notice on the Publication of Management Methods for the Demonstration Project for Building World-Class Cybersecurity Colleges,' Cyberspace Administration of China (CAC, and 国家互联网信息办公室), Center for Security and Emerging Technology, August 14, 2017, https://cset.georgetown.edu/publication/notice-on-the-publication-of-management-methods-for-the-demonstration-project-for-building-world-class-cybersecurity-colleges/.

[2] National Security Agency, "National Centers of Academic Excellence in Cybersecurity," accessed June 29, 2021, https://www.nsa.gov/resources/students-educators/centers-academic-excellence/.

[3] The NCS's six federal partners include the Cybersecurity and Infrastructure Security Agency, the Federal Bureau of Investigation, the National Institute of Standards and Technology (NIST)/National Initiative on Cybersecurity Education (NICE), the National Science Foundation, the Department of Defense Office of the Chief Information Officer, and US Cyber Command.

[4] "一流网络安全学院建设示范项目高校增至11所," 中共中央网络安全和信息化委员会办公室, September 17, 2019, https://perma.cc/YT29-C8DU?type=image.

[5] "一流网络安全学院建设示范项目高校增至11所," 中共中央网络安全和信息化委员会办公室.

[6] "一流网络安全学院建设示范项目高校增至11所," 中共中央网络安全和信息化委员会办公室.

[7] 崔光耀, "漫说网络安人才的热点和难点," 中国信息安全, December 15, 2018.

[8] 苏雨辰and 战略支援部队信息工程大学, "高素质网络空间安全人才特点及培养规律分析," 网信军民融合, April 25, 2019.

[9] "战略支援部队与地方9个单位合作培养新型作战力量高端人才," 中华人民共和国国防部, July 12, 2017, https://perma.cc/PM8L-3WU4.

[10] This report chose the CAE-Cyber Operations certification because it is more technically rigorous than the CAE-Cyber Defense Education, it is not offered to

associate degree programs, and, consequently, obtained by fewer institutions. Conversely, the CAE-Cyber Research certification is not comparable to China's WCCS designation; the CAE-CR certification is awarded to PhD awarding R1 or R2 institutions or DoD schools. See "National Centers of Academic Excellence in Cybersecurity" (National Cryptologic School, 2020), https://www.caecommunity.org/sites/default/files/CAE_Book_Version_2.0_Compressed.pdf.

[11] National Security Agency, "Academic Requirements for Designation as a CAE in Cyber Operations Fundamental," accessed June 29, 2021, https://www.nsa.gov/Resources/Students-Educators/centers-academic-excellence/cae-co-fundamental/requirements/.

[12] "网络空间安全," 西安电子科技大学网络与信息安全学院, November 15, 2017, https://perma.cc/EYZ8-CN82?type=image.

[13] "教师名录," 武汉大学国家网络安全学院, accessed June 29, 2021, https://perma.cc/28NP-XWJD?type=image;. "教师名录副教授," 武汉大学国家网络安全学院, accessed June 29, 2021, https://perma.cc/Z6VM-44PK?type=image.

[14] "直接攻读博士学位必修课程环节设置及学分要求," 北航网络空间安全学院, May 30, 2018, https://perma.cc/V4GE-GDSJ?type=image.

[15] "网络空间安全（0839）学科研究生培养方案," 中国科学技术大学网络空间安全学院, October 30, 2018. https://perma.cc/VLP8-FSLX?type=image.
[16] "2020年网络空间安全学院硕士专业目录," 北京邮电大学网络空间安全学院, September 12, 2019, https://perma.cc/YHJ5-PPVM?type=image.
[17] "专业介绍," 山东大学网络空间安全学院, accessed June 29, 2021, https://perma.cc/6Q3N-2424?type=image. Undergraduate course catalogues are available only via download.

[18] "Introduction to Artificial Intelligence," 四川大学网网络空间安全学院, accessed June 29, 2021, https://perma.cc/J7M8-EAX6; 考研帮, "2020年网络空间安全研究院硕士研究生招生专业目录," 四川大学网络空间安全学院, September 28, 2019, https://perma.cc/6QFT-CC5E?type=image.
[19] "博士生培养: 网络空间安全," 东南大学网络安全学院, accessed June 29, 2021, https://perma.cc/2CBY-AMWT?type=image; "硕士生培养: 网络空间安全" 东南大学网络安全学院, accessed June 29, 2021, https://perma.cc/JY2L-3ZTK?type=image; "东南大学 2018级 网络空间安全 本科专业培养方案," 东南大学网络安全学院, accessed June 29, 2021, https://perma.cc/HE9G-666L?type=image.
[20] "本科生: 课程介绍," 上海交通大学网络空间安全学院, accessed June 29, 2021, https://perma.cc/K4HC-CV27?type=image; "硕士研究生: 课程介绍,"

上海交通大学 网络空间安全学院, accessed June 29, 2021, https://perma.cc/Z3VL-VHQD?type=image; "博士研究生: 课程介绍," 上海交通大学网络空间安全学院, accessed June 29, 2021, https://perma.cc/EP47-S4NL?type=image.

21 Graham Webster, Rogier Creemers, Paul Triolo, and Elsa Kania, "Full Translation: China's 'New Generation Artificial Intelligence Development Plan' (2017)," New America, August 1, 2017. https://www.newamerica.org/cybersecurity-initiative/digichina/blog/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/. Author's note: although both policy documents referenced here discuss "AI" for cybersecurity, the RHG and CGC did not use what most experts would call AI. Instead, these automated systems relied on prescribed reasoning systems to make decisions. None used machine learning, deep learning, reinforcement learning, or any other framework typically associated with AI.

22 Paul Triolo, Elsa Kania, and Graham Webster, "Translation: Chinese Government Outlines AI Ambitions through 2020," New America, January 26, 2018, https://www.newamerica.org/cybersecurity-initiative/digichina/blog/translation-chinese-government-outlines-ai-ambitions-through-2020/.

23 "World University Rankings 2021," Times Higher Education, August 25, 2020, https://www.timeshighereducation.com/world-university-rankings/2021/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats.

24 Dakota Cary, "China's National Cybersecurity Center: A Base for Military-Civil Fusion in the Cyber Domain" (Center for Security and Emerging Technology, July 2021), https://cset.georgetown.edu/publication/chinas-national-cybersecurity-center/.

25 Dakota Cary, "Academics, AI, and APTs: How Six Advanced Persistent Threat-Connected Chinese Universities Are Advancing AI Research" (Center for Security and Emerging Technology, March 2021), https://doi.org/10.51593/2020ca010.

26 "习近平总书记在网络安全和信息化工作座谈会上的讲话," 中共中央网络安全和信息化委员会办公室, April 19, 2016, https://perma.cc/JW2N-22BH?type=image.

27 Karen Marrongelle and Margaret Martonosi, "Dear Colleague Letter: Cybersecurity Education in the Age of Artificial Intelligence (NSF 20-072)," National Science Foundation, April 6, 2020, https://www.nsf.gov/pubs/2020/nsf20072/nsf20072.jsp.

28 Cyber Security and Information Assurance Interagency Working Group, Subcommittee on Networking & Information Technology Research &

Development, Committee on Science & Technology Enterprise of the National Science & Technology Council, "Federal Cybersecurity Research and Development Strategic Plan," Executive Office of the President of the United States, https://www.nitrd.gov/pubs/Federal-Cybersecurity-RD-Strategic-Plan-2019.pdf.

[29] "NSF Award Search: Advanced Search Results," National Science Foundation, accessed June 29, 2021, https://perma.cc/SZ6S-D94H?type=image; "NSF Award Search: Advanced Search Results II," National Science Foundation, accessed June 29, 2021, https://www.nsf.gov/awardsearch/advancedSearchResult?PIId=&PIFirstName=&PILastName=&PIOrganization=&PIState=&PIZip=&PICountry=&ProgOrganization=&ProgEleCode=8060&BooleanElement=All&ProgRefCode=025Z%2C+093Z%2C+7916&BooleanRef=All&Program=&ProgOfficer=&Keyw.

[30] "一流网络安全学院建设示范项目高校增至11所," 中共中央网络安全和信息化委员会办公室, September 17, 2021, https://perma.cc/V6GU-SL6E?type=image.
[31] "网络空间安全," 西安电子科技大学网络与信息安全学院, November 15, 2017, https://perma.cc/J7B5-S7TP?type=image.
[32] "一流网络安全学院建设示范项目高校增至11所," 中共中央网络安全和信息化委员会办公室, September 17, 2021, https://perma.cc/2EFF-MPCC?type=image.
[33] "学术报告," 武汉大学国家网络安全学院, December 24, 2019, https://perma.cc/4USH-P9B5?type=image.

[34] Cary, "China's National Cybersecurity Center: A Base for Military-Civil Fusion in the Cyber Domain."

[35] "一流网络安全学院建设示范项目高校增至11所," 中共中央网络安全和信息化委员会办公室, September 17, 2021, https://perma.cc/FRG4-7T3G?type=image.

[36] "直接攻读博士学位必修课程环节设置及学分要求," 北航网络空间安全学院, May 30, 2018, https://perma.cc/82VU-XEVZ?type=image.

[37] "一流网络安全学院建设示范项目高校增至11所," 中共中央网络安全和信息化委员会办公室, September 17, 2021. https://perma.cc/L69R-P7QY?type=image.

[38] "网络空间安全（0839）学科研究生培养方案," 中国科学技术大学网络空间安全学院, October 30, 2018, https://perma.cc/TPK3-XPWA?type=image.

39 "网络空间安全（0839）学科研究生培养方案,"
中国科学技术大学网络空间安全学院.

40 "王小谟网络空间科技英才班培养计划（19级开始实行）,"
中国科学技术大学网络空间安全学院, August 30, 2018, https://perma.cc/LJ2U-689S?type=image.

41 "一流网络安全学院建设示范项目高校增至11所,"
中共中央网络安全和信息化委员会办公室, September 17, 2021,
https://perma.cc/L69R-P7QY?type=image.

42 "一流网络安全学院建设示范项目高校增至11所,"
中共中央网络安全和信息化委员会办公室.

43 "网络空间安全学院," 华中科技大学网络空间安全学院, July 20, 2020,
https://perma.cc/8NVP-X74M?type=image.

44 Cary, "China's National Cybersecurity Center: A Base for Military-Civil Fusion in the Cyber Domain."

45 "一流网络安全学院建设示范项目高校增至11所,"
中共中央网络安全和信息化委员会办公室.

46 "2020年网络空间安全学院硕士专业目录," 北京邮电大学网络空间安全学院,
September 12, 2019, https://perma.cc/P6U6-6TXK?type=image.

47 "2020年网络空间安全学院博士专业目录," 北京邮电大学网络空间安全学院.

48 "一流网络安全学院建设示范项目高校增至11所,"
中共中央网络安全和信息化委员会办公室.

49 "专业介绍," 山东大学网络空间安全学院, accessed June 29, 2021,
https://perma.cc/SD47-KZ7E?type=image. Undergraduate course catalogues are available only via download.

50 "一流网络安全学院建设示范项目高校增至11所,"
中共中央网络安全和信息化委员会办公室.

51 考研帮, "2020年网络空间安全研究院硕士研究生招生专业目录,"
四川大学网络空间安全学院, September 28, 2019, https://perma.cc/M4XW-UE7J?type=image; "Introduction to Artificial Intelligence,"
四川大学网网络空间安全学院, accessed June 29, 2021, https://perma.cc/J7M8-EAX6.

52 "一流网络安全学院建设示范项目高校增至11所,"
中共中央网络安全和信息化委员会办公室.

[53] "博士生培养," 东南大学网络安全学院, accessed June 29, 2021, https://perma.cc/PJB8-VL4F?type=image; "硕士生培养：网络空间安全," 东南大学网络安全学院, accessed June 29, 2021, https://perma.cc/D4DL-UVDK?type=image; "东南大学 2018级 网络空间安全 本科专业培养方案," 东南大学网络安全学院, accessed June 29, 2021, https://perma.cc/PKU9-7HGM?type=image.

[54] "一流网络安全学院建设示范项目高校增至11所," 中共中央网络安全和信息化委员会办公室.

[55] "本科生课程介绍," 上海交通大学网络空间安全学院, accessed June 29, 2021, https://perma.cc/T8JC-774Z?type=image; "硕士研究生课程介绍," 上海交通大学网络空间安全学院, accessed June 29, 2021, https://perma.cc/JQA9-4HQC?type=image; "博士研究生课程介绍," 上海交通大学网络空间安全学院, accessed June 29, 2021, https://perma.cc/CQ2R-EYYU?type=image.

[56] "Curriculum Fall 2020 (MS32) - Information Networking Institute," Carnegie Mellon University College of Engineering, accessed June 29, 2021, https://www.cmu.edu/ini/academics/msis/curriculum_ms32.html.

[57] "2020-21 Undergraduate Academic Catalog," Cedarville University, accessed June 29, 2021, https://publications.cedarville.edu/academiccatalogs/2020-2021/#119.

[58] "Plan of Study - Bachelor of Science Cyber Operations," Dakota State University, 2020, https://dsu.edu/programs/files/Cyber-Operations-MAP-20-21.pdf.

[59] "Graduate Certificate in Cyber Operations," Mississippi State University Computer Science and Engineering Department, April 2018, https://www.cse.msstate.edu/wp-content/uploads/2018/04/GCO-Certificate-Application.pdf.

[60] "Cyber Systems and Operations (CSO) - Curriculum 326," Naval Postgraduate School, accessed June 29, 2021, https://nps.smartcatalogiq.com/Current/Academic-Catalog/Graduate-School-of-Operational-and-Information-Sciences-GSOIS/Cyber-Academic-Group/Copy-of-Cyber-Systems-and-Operations-CSO-Curriculum-326.

[61] "Cybersecurity, BS," Northeastern University, accessed June 29, 2021, http://catalog.northeastern.edu/undergraduate/computer-information-science/cybersecurity/cybersecurity-bs/.

[62] "Cybersecurity, M.S.," New York University Tandon School of Engineering, accessed June 29, 2021,

http://bulletin.engineering.nyu.edu/preview_program.php?catoid=15&poid=4341&hl=CS-GY6033&returnto=search.

63 "School of Cybersecurity," Old Dominion University, accessed June 29, 2021, https://catalog.odu.edu/undergraduate/schoolofcybersecurity/.

64 "Computer Science BS," Texas A&M University, accessed June 29, 2021, https://catalog.tamu.edu/undergraduate/engineering/computer-science/bs/.

65 "Major in Computer Science - Cyber Operations Track." Towson University, accessed June 29, 2021, https://catalog.towson.edu/undergraduate/fisher-science-mathematics/computer-information-sciences/computer-science-cyber-operations/.

66 "Cyber Science," United States Air Force Academy, accessed June 29, 2021, https://www.usafa.edu/academic/cyber-science/.

67 "Cyber Operations Curriculum," University of Arizona, accessed June 29, 2021, http://cyber-operations.uas.arizona.edu/content/curriculum.

68 "Cyber Operations Certificate," University of Cincinnati, accessed June 29, 2021, https://webapps2.uc.edu/ecurriculum/DegreePrograms/Home/MajorMap/3436.

69 "Bachelor of Science in Cybersecurity – Cyber Operations Track," University of Nebraska Omaha School of Interdisciplinary Informatics, accessed June 29, 2021, https://www.unomaha.edu/college-of-information-science-and-technology/school-of-interdisciplinary-informatics/cybersecurity/bs-cyber-operations.php.

70 "Computer Science, B.S., Cybersecurity Concentration," University of New Haven, accessed June 29, 2021, http://catalog.newhaven.edu/preview_program.php?catoid=22&poid=5982.

71 "Graduate Program in Computer Science," University of Texas at Dallas, accessed June 29, 2021, https://catalog.utdallas.edu/now/graduate/programs/ecs/computer-science.

72 "BS in Computer Science," University of Texas at Al Paso, accessed June 29, 2021, http://catalog.utep.edu/undergrad/college-of-engineering/computer-science/computer-science-bs/.

73 "Cyber Operations Track," University of Texas at San Antonio, accessed June 29, 2021, https://cs.utsa.edu/cyberoperations/.

74 "Cyber Security, M.S," University of Tulsa, accessed June 29, 2021, https://bulletin.utulsa.edu/preview_program.php?catoid=27&poid=3978.

75 "Minor in Cybersecurity," Virginia Tech College of Engineering, accessed June 29, 2021, https://ece.vt.edu/undergrad/curriculum/cybersecurity/.