

Coding is the New Coal: A History of Integrating Computer Science Across Wyoming's K-12 Curriculum

Prof. Astrid K. Northrup P.E., Northwest College

Astrid Northrup earned her B.S. degree in petroleum engineering from the Montana College of Mineral Science and Technology (Montana Tech) in 1984 and her M.S. degree in petroleum engineering from Montana Tech in 1986. She also earned a Certificate in Land Surveying from the University of Wyoming in 2005. She is a registered Professional Engineer in Colorado and Wyoming. She worked in the petroleum industry as a reservoir engineer and as a private consultant before moving into a teaching career at Northwest College in Powell WY, where she is Professor of Engineering Science and Mathematics and Division Chair of Physical Science. She is pursuing a Ph.D. in Science Education at the University of Wyoming in Laramie. She is married to David and has three adult sons.

Dr. Raymond Edward Floyd, Northwest College

Raymond E. Floyd (M'63 – SM'85 – LSM'03) He has a BSEE from Florida Institute of Technology, Melbourne, FL – 1970, an MSEE from Florida Atlantic University, Boca Raton, FL – 1977, and a PhD in Engineering Management from California Coast University, Santa Ana, CA - 2009. He spent 26 years with IBM, retiring as a Senior Engineer in 1992. He is currently a Visiting Lecturer at Northwest College in Powell, WY. He has published over 200 papers on a variety of topics. He most recently co-authored a text, *Perspectives on Engineering* (2011), an IEEE eBook, *Shaping an Engineering Career: Book 2: Dual Career Ladders* (2013), and another text, *So You Want to be an Engineer?* (2015).

Dr. S. Renee Dechert, Northwest College

Renee Dechert is a professor of English at Northwest College in Powell, Wyoming, where she teaches courses in technical writing, business communication, composition, and social media. Her current research focus is on the rhetoric of social media. She also blogs about the Colorado Rockies.

Dr. Andrea Carneal Burrows, University of Wyoming

Dr. Andrea C. Burrows is a Professor at the University of Wyoming (UW) in the College of Education's (CoEd) School of Teacher Education. She received her doctorate degree from the University of Cincinnati in 2011. She was awarded the UW CoEd Early Career Fellowship (2013), UW CoEd Faculty Award for Outstanding Research & Scholarship (2015), UW CoEd Faculty Award for Outstanding Service to the Education Profession (2016), UW CoEd Honored Fall Convocation Faculty (2017), and UW CoEd Faculty Award for Outstanding Research & Scholarship (2019). She won an Outstanding Reviewer award for MDPI's Education Sciences journal (2020) and ASTE's Outstanding Science Teacher Educator of the Year (2021). Since beginning at UW, Burrows has written, implemented, or evaluated over 50 unique grants. She has been the Program Director for GenCyber as well as PI of NSF grants for STEM and CS work with 9.5+ million in funding. The core of her research agenda is to deepen science, mathematics, engineering, and technology (STEM) partnership involvement and understanding through STEM interdisciplinary integration with in-service teacher professional development (PD) and pre-service teacher coursework. Her research agenda is composed of a unified STEM education partnership structure and connects educational research to real-world practices. Burrows' many publications appear in leading journals. She is the Co-Editor of CITE-Journal Science (www.citejournal.org). She is active and presents in several organizations (such as AERA, ASEE, ASTE, NSTA, and SITE.), and she is the current chair-elect for the ASEE PCEE Division. Before beginning her work in higher education, she taught secondary school science for 12 years in Florida and Virginia (USA).

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Astrid K. Northrup, S. Renee Dechert, and Raymond Floyd
Northwest College

Andrea C. Burrows
University of Wyoming

Abstract

Historically, Wyoming has depended on coal and petroleum as the foundation of the state's tax base. With revenue from these sources in decline, Wyoming lawmakers began the process of transforming the state's economy, with a focus on encouraging the growth of high-tech industries. As a first step, in 2019, the Wyoming State Legislature passed a bill mandating computer science at all levels of K-12 public education to encourage universal computer literacy. Based on this legislation, the Wyoming Department of Education wrote computer science standards, which were accepted in February 2020. While the Wyoming State School Board is currently working to approve those standards, Wyoming's higher education system (the University of Wyoming and seven community colleges) has begun implementing K-12 Computer Science Endorsement programs in accordance with the Wyoming Professional Teaching Standards Board.

In the summer of 2020, Northwest College (NWC), a two-year college located in rural Wyoming, launched its program to a cohort of K-12 teachers. The endorsement program includes courses in structured programming, application development, cyber citizenship, and robotics. The first cohort will graduate in May 2021 and will be certified to teach computer science in Wyoming's public schools.

This paper outlines the process for curriculum development, problem solving, and instructional strategies employed by those NWC faculty teaching the cohort. The experiences of the teachers enrolled in the first cohort will be a topic of future study.

Coding Is the New Coal: A History of Integrating Compute Science in Wyoming

Two contributing factors have guided the move to introduce computer science into Wyoming's K-12 curriculum. The first was the decline of Wyoming's primary industry, the production of coal and the 20% reduction in demand as the production of electricity moves to natural gas or other renewable resources (Wyoming Mining Association, 2013). As a result of the reduced demand for coal, the state's tax revenue has been significantly reduced, which is reflected in monies available for the educational system (Frosch, 2019).

The second factor has been the increased demand for the introduction of an Associate of Science degree in Computer science at NWC and the need to provide certification training for K-12 teachers within the college's service area. As a result of the demand to provide necessary training, former Governor Matt Mead issued a directive to modify the K-12 curriculum to include material covering computer science, both its use and understanding. This was implemented through the Wyoming Legislature (SF0029, 2018). Specifically, the bill did the following:

- Added "computer science" to the common Core of Knowledge.
- Added "computational thinking" to the Common core of Skills.
- Authorized students to use a computer science course to satisfy one year of the high school graduation requirement and one year of science or math in the Hathaway Success Curriculum.

During the same period, NWC had been reviewing its computer science program offerings. There were three inactive computer science programs in the college catalog that were reintroduced to the curriculum (Northwest College, 2018):

- COSC 1010, Introduction to Computer Science

- COSC 1030, Computer Science I
- COSC 2030, Computer Science II

The courses had not been offered for some time and required revision and alignment with the program offered at the University of Wyoming (UW). In addition to the current offerings the following courses were added to the Northwest College Catalog (2020):

- COSC 2150, Computer Organization
- MATH 2300, Discrete Structures

These courses were added to complete the offerings for the relaunched Associate of Science (AS) in Computer Science degree. The courses were loosely aligned with similar offerings from UW to allow students to transfer credits earned at NWC into the Bachelor of Science in Computer Science program at UW. Using those three courses as the basis for an AS degree program, the additional courses in computer architecture and mathematical structures were added to round out the degree requirements to align more closely with UW's degree.

The content for the three existing courses emphasized a variety of programming languages to develop students' skills. COSC 1010 uses a high-level language (MATLAB) to introduce programming concepts, program debug skills, and general solution development for computer and other technical programs. COSC 1030 and COSC 2030 provide a more in-depth look at programming, this time at the machine level, commonly referred to as "assembler language level." Again, the emphasis is on problem-solution development, program debug, and understanding machine operation. COSC 2150 offers a review of computer history from the days of Turing to modern integrated circuits. The course provides insight into systems from the central processor unit (CPU) to a variety of input/output devices.

Discussion

In the 2015 interim legislative session, former Governor Mead's office requested the Legislature to study STEM opportunities and careers for students in an effort to decrease the skills gap for career and technical occupations (Legislative Service Officer Wilmarth, personal communication, 2020). The legislative committee, however, did not forward any legislation implementing this initiative. The Governor's office then created a task force for this purpose and established the "Governor's Cup Competition" for high school students in an effort to recognize the most innovative and creative technology that provided solutions to problems facing Wyoming and its citizens.

In 2017 a legislative committee again studied computer science. The committee sponsored 18LSO0221 "Education - computer science and computational thinking" at its November 14 meeting for sponsorship during the 2019 Budget Session after two previous meetings formed the discussion for the bill draft. The bill was passed as SF0029, "Education - computer science and computational thinking."

Following legislation, the path to implementation of NWC's K-12 Computer Science Endorsement program was as follows:

- Wyoming Department of Education Computer Science Content Standards (Wyoming Computer Science Standards, 2019)
- Wyoming State School Board Debate/Public Comment process
- Professional Teaching Standards Board approval (PTSB, 2020)
- Wyoming Community College Commission approval (WCCC, 2020)
- NWC's Curriculum Committee approval (NWC CC, 2020)
- Inclusion of Introduction to Computer Science and Computer Science I in all statewide

programs

- Inclusion of additional specialized courses that varied from additional computer science courses to social media and web design
- Requirement in all endorsement programs of between 15 and 20 credit hours for completion

Six of Wyoming's community colleges and UW have created K-12 Computer Science Endorsement programs. A comparison of these programs shows that despite some common elements, each program is different. Table 1 in the Appendix compares the courses required for each of the seven endorsement programs.

In response to SF0029, the Wyoming Department of Education developed the Wyoming Computer Science Content Standards. These standards are based upon seven practices, described as follows in the Wyoming computer Science Standards (2019):

- Practice 1. Fostering an Inclusive Computing Culture
- Practice 2. Collaborating Around Computing
- Practice 3. Recognizing and Defining Computational Problems
- Practice 4. Developing and Using Abstractions
- Practice 5. Creating Computational Artifacts
- Practice 6. Testing and Refining Computational Artifacts
- Practice 7. Communicating About Computing

In developing the curriculum for the NWC K-12 Computer Science Endorsement program, the faculty realized that Practices 3-6 were addressed in traditional computer science classes (COSC 1010 and 1030), but Practices 1, 2, and 7 were broader and needed to be addressed in new ways. To address these practices, three new or re-envisioned courses were added:

- ES 2200, Robotics
- ENGL 2002, Social Media for K-12 Teachers
- COSC 2002, Application Development

Robotics is a one credit, hands on course using Lego robots and drones to assist teachers in mentoring students by forming robotics teams and preparing for competition. This directly addresses collaboration (Practice 2) and computational problem recognition (Practice 3).

NWC also created Social Media for K-12 Teachers and Application Development. While other courses in this program were used in a modified or unmodified version, these courses were developed specifically for the K-12 Computer Science Endorsement program. Social Media for K-12 Teachers focuses on cyber citizenship, ethics, and the responsible use of social media in the classroom. Discussion forums and sharing of computational artifacts (lesson plans and demonstrations) were central to the structure of this class to address Practice 1 (Fostering an Inclusive Computing Culture in an exploration of cyber citizenship), Practice 2 (Collaborating Around Computing in the creation and sharing of computer artifacts), and Practice 7 (Communicating About Computing). Application Development reinforces computational thinking and traditional programming skills (Practices 5 & 6) in the development of artifacts that have immediate classroom applications.

To summarize, with the directive issues by former Governor Mead, and the Practices outlined in the Wyoming Computer Science Standards, it became clear that COSC 1010, Introduction to Computer Science and COSC 1030, Computer Science I would be the basis of NWC's K-12 Computer Science Endorsement program. We added ES 2200, Robotics, ENGL 2002, Social Media for K-12 Teachers, and COSC 2002, Application Development to address all seven practices set forth in the Wyoming Computer Science Standards and to prepare our cohort

of teachers to immediately apply their knowledge in their classrooms. These 5 courses total 15 semester credit hours and may be completed in one calendar year.

First Cohort

The original class consisted of 21 teachers from several schools within the college's service area. At the end of the program, 15 teachers completed all five of the program offerings, thus earning their K-12 Computer Science endorsement. Feedback from cohort members indicated that although the program offerings were difficult, they found the information to be valuable and said that it would be applied in their work when they returned to school. One of the greatest challenges was that the program occurred during the COVID-19 pandemic, and four of the five classes had to be conducted via ZOOM. ES 2200, robotics was delayed so that it could be offered in a face-to face setting. A second challenge was in the additional workload for teachers who were completing coursework while carrying regular teaching loads.

Curriculum Implementation

The two required computer science courses were already NWC catalog courses. Both were implemented without modification. Robotics was revised from an existing course to make its content more relevant for the cohort, while Application Development and Social Media for K-12 teachers were specifically developed for this endorsement program. A brief description of each course in the endorsement program follows.

Introduction to Computer Science

In COSC 1010, Introduction to Computer Science, the teachers were introduced to a commonly used programming language, MATLAB. Although the programming language is "English-like," some of the teachers had difficulty applying the language to the problems assigned. Students struggled with tasks as simple as asking the user to input a particular

character/letter and determining if the correct letter had been introduced using the IF/ELSE construct. Introduction to Computer Science addresses Practices 3,4,5 and 6 of the Wyoming Computer Science Content Standards (2019).

Computer Science I

In COSC 1030, Computer Science I, the concept of programming at the machine level was introduced. This presented a challenge to most of the teachers because it was unlike any computer usage they had experienced. Computer Science I addresses Practices 3,4,5 and 6 of the Wyoming Computer Science Content Standards (2019).

Social Media for K-12 Teachers

In ENGL 2002, Social Media for K-12 Teachers, the cohort explored the implications of social media. The course was designed to familiarize the cohort with the most popular social media platforms, to explore those platforms' potential use in the classroom, and to consider the implications of digital citizenship. Kristen Mattson's (2017) *Digital citizenship in action: Empowering students to engage online* provided a springboard for course discussions that focused on platforms ranging from Facebook and Twitter to Discord and Twitch. Each teacher selected a platform and then created a brief video presentation addressing topics (e.g., user traffic and demographics, classroom possibilities and pitfalls) and then facilitated a discussion. Finally, the course concluded with students submitting a research project. The topics were varied (everything from lesson plans to ethnographies to more personal responses), but each addressed practical classroom uses and issues. Social Media for K-12 Teachers addresses Practices 1, 2 and 7 of the Wyoming Computer Science Content Standards (2019).

Application Development

COSC 2002, Application Development, focused on creating computer-centered lesson plans for immediate classroom use. The course consisted of three modules. In the first module, the programming language EXCEL was used to illustrate the values of an object-oriented programming language. EXCEL can be used to introduce computers into the K-12 curriculum with useful applications, such as graphing, record keeping, and grade books.

The second module used micro:bits and the Python programming language. The teachers were given micro:bits, which were purchased using funds from a STEM endowment administered through NWC's foundation. After the use of micro:bits and the Python programming language were introduced, the teachers researched material on open-source websites (such as code.org) to choose and develop a lesson plan for their classes. They then demonstrated the lesson by making a video and sharing it with the class.

The final module consisted of students applying what they had learned in an educational environment. The projects were varied: Some attempted to "hack" their current Learning Management System (LMS) to address an operating problem; some wrote curricula for their school's standards; others created lesson plans. Application Development addresses Practices 3, 4, 5 and 6 of the Wyoming Computer Science Content Standards (2019).

Robotics

ES 2200, Robotics is the final class in NWC's K-12 Computer Science Endorsement program. It is the only face-to-face class, consisting of 16 hours of instruction. These hours will be spread over 2 days in May and June 2021. The first day will be devoted to programming Lego robots using EV3 and RobotC languages, and will focus on teaching competitive robotics. The second day will focus on programming UAVs (drones) in the Swift language, again with an

emphasis on competition. In the event that a face-to-face experience is not possible, teachers had the option of substituting ITEC 2360, Teaching with Technology, which is offered online. Robotics addresses Practices 2 and 3 of the Wyoming Computer Science Content Standards (2019).

Further Steps

After working through the first cohort, the schedule was adjusted, and NWC's K-12 Computer Science Endorsement will be refined.

The teachers initially completed one course in the summer semester, two in the fall, one in the spring, and finished with Robotics the following summer. The teachers expressed an interest in having fewer courses during their school year, so Social Media for K-12 Teachers was moved to the summer to be taken concurrently with Introduction to Computer Science and Robotics. The teachers in the second cohort will then take Computer Science I in the fall and Application Development in the spring; they will be awarded their K-12 Computer Science Endorsements in May. This arrangement will allow the teacher to do more of their coursework during the summer, when they are not also teaching.

Further refinement of the curriculum, including a focus on particular programming languages, will be determined in cooperation with instructors and student feedback. Based on the results of the initial offering, the general format was found to be effective. Future classes will follow the same general outline, with modifications to schedule and content to be determined by the general success of class to class.

The future requires fundamental knowledge of computers in the public domain. As a result, NWC will continue to serve its constituency and meet its mission by refining our K-12 Computer Science Endorsement program to remain relevant over time.

Wyoming's economic past is based on jobs generated by coal and other extractive minerals, but Wyoming's economic future is based on technology. As Wyoming lawmakers began the process of economic transformation, their vision focused on encouraging the growth of high-tech industries within our state. Preparing new generations of Wyoming K-12 students for high-tech jobs is fundamentally important to that vision. Universal computer science education will prepare Wyoming students for the future, and it all starts with Wyoming teachers leading the charge. Universal K-12 computer science education will be the foundation of our transformed economy: in this way, coding will be the new coal.

References

- 2019 Wyoming computer science content standards (2019, February 4). Retrieved from <https://edu.wyoming.gov/wp-content/uploads/2020/02/Computer-Science-Standards-2019-02.04.20-Approved.pdf>
- Computer science teachers association K-12 standards (2017). Retrieved from <https://www.csteachers.org/page/about-csta-s-k-12-nbsp-standards>
- Frosch, D. (2019, September 4). Wall Street Journal, *Coal mine closures shake Wyoming*.
- The hub for computer science in Wyoming (n.d.). Retrieved from <https://www.uwyo.edu/wy/cs/>
- Mattson, K. (2017). *Digital citizenship in action: Empowering students to engage in online communities*. International Society for Technology in Education.
- Northwest College (2018). *2018-2019 Northwest College catalog*. Retrieved from <https://catalog.nwc.edu/content.php?catoid-9&navoid=1195>
- Northwest College (2020). *2020-2021 Northwest College catalog*. Retrieved from <https://catalog.nwc.edu/content.php?catoid-12&navoid=1370>
- Northwest College Curriculum Committee (2019). Item 1: *Minutes of the regular meeting of the NWC Curriculum Committee, December 10, 2019, MB 112, NWC campus*.
- Professional Teaching Standard Board 92020). Item 6.b: “Computer science endorsement program approval applications.” *Minutes of the regular meeting of the Wyoming PTSB, January 2020*, virtual meeting, Google hangouts.
- Wyoming Community College Commission (2020). Item F.1. *Minutes of the regular meeting of the WCCC, April 16, 2020, held remotely via ZOOM*.
- Wyoming Mining Association (2013, May 31). *The concise guide to Wyoming coal*. Retrieved from <http://www.wyomingmining.org/wp-content/uploads/2013,11,2013-14-Concise-Guide-to-Wyoming-Coal.pdf>
- Wyoming 2017 Legislative session, 18LSO0221. “Education-computer science and computational thinking,” November 14, 2017.
- Wyoming 2019 Senate Bill 29. “Education-computer science and computational thinking.” Retrieved from <https://legiscan.com/WY/bill/F0029/2018>.

Appendix

Comparison of Wyoming Computer Science endorsement programs

Course Name	Credits	NWC	UW	WWCC	CWC	NWCCD	CC	LCCC
Intro to CoSci	4	X	X	X	X	X	X	X
CoSci I	4	X	X	X	X	E	X	X
App. Dev.	3	X						
Intro. Robotics	1	X						
Soc. Media K-12 Teachers	3	X						
Teaching with Tech	3			X		E	X	X
CoSci II	4		X		E			E
Web Authoring	3					X		E
Web Prog. I	3					X	X	
Intro. SQL	3					X		
Comp. Org	3		X					
Web App.Dev.	3						X	
Python Prog	3							X
CoSci Capstone	1			X				
Ethics	1		X					
CS Ed Sem.	2		X					
WebDev I	3			X				
Comp.Prog.	3				X			
CS Methods	2		X					
Scripting Lang	3					E		
Web Prog. II	3					E		
Intro. Linux	3				E			
Ntwk. Security Fund	3				E			
Intro. Networking	3				E			
Intro.Database App.	1							E
Database App.	3							E
Hardware Maint.	4				E			
Total Credits		15	20	15	15	15	17	15-18

Note. From the minutes of the regular meeting of the Professional Teaching Standards Board (PTSB), 27 January 2020.

X -Required course; E – Elective course

WWCC – Western Wyoming Community College

CWC – Central Wyoming Community College

NWCCD – Northwest Wyoming Community College District

CC – Casper College

LCCC – Laramie County Community College

Note. The UW endorsement program has been changed since the PTSB meeting. UW currently offers Basic/Intermediate and Intermediate/Advanced endorsements for 15 and 16 credits, respectively (“The Hub for Computer Science Outreach in Wyoming,” n.d.)