Computer Science Education Graduate Certificate Program
DRAFT (5-9-21)

In May, 2019, the UVM Board of Trustees approved the creation of a new Computer Science Education (CSE) Minor and Major Concentration for undergraduate students interested in 7-12 licensure in Computer Science. Approval followed a year-long process during which faculty from the College of Education (CESS) Department of Education partnered with faculty from the Computer Science Department in the College of Engineering and Mathematical Sciences (CEMS) to develop, propose, and achieve approval for CSE Minor and Concentration options. In March, 2020 UVM's Computer Science Education minor and major concentration were reviewed and subsequently approved through the AOE ROPA and VT Standards Board as programs that meet state needs for additional opportunities for teacher candidates, teachers and other professionals to achieve proficiency as Computer Science educators. Documentation that supports the AOE ROPA approval of the UVM's Computer Science Education minor and major concentration for licensure endorsement is available upon request.

In 2019, a state-wide survey of Vermont teachers (n=270) reported that 51% of respondents engaged students in some form of CS activities including Code.org hour of code, Lego robotics, makerspace or other coding activities. Approximately 20% reported having after-school computer clubs and 27% engaged in CS professional development. In 2017, approximately 200 new teachers were prepared to teach CS in the US (Ed.gov, 2019); however, no teachers graduated from a Vermont institute of higher education prepared to teach CS during this period (Code.org, 2018b). To date, only 27 teachers are licensed to teach CS in grades 7-12 in VT.

This request to the Vermont Standards Board for Professional Educators seeks approval for a **Computer Science Education Graduate Certificate Program** designed for in-service secondary teachers (grades 7-12) interested in pursuing licensure through a graduate certificate program that fully aligns to the AOE Computer Science Endorsement Standards and to the CS coursework and minor that were previously approved in March 2020 by the VT Standards Board.

The CSE Graduate Certificate Program is a year-long 18-credit program that includes 2 hybrid (in person and/or remote) institutes offered in Summers 1 and 2 (online if COVID-19 restrictions still exist) and quarterly online classes offered in the evening and weekends during the academic year (August through May). Options for part-time enrollment are possible for those requiring a more flexible program (See Table 1.)

The Computer Science Graduate Certificate coursework covers the same computer science content approved for UVM's Computer Science Education minor and major concentration and is fully aligned to the AOE Computer Science Education Standards (See Table 1). CS content emphasized in the Graduate Certificate will include the following:

- Web design provides a strong foundation in HTML, CSS, images, beginning web programming, and web design so that teachers and their students can create a complete functional web site.
- Introductory Programming provides an introduction to algorithmic problem solving and computer programming and is designed to provide a foundation for further studies in CS.
- Discrete Structures provides an introduction to analytic and formal methods of CS with practical examples, including analysis or data structures, recursion relations, proof methods, and logic programming.
- Intermediate Programming includes common data structures, algorithms, style, design,

documentation, testing and debugging techniques as well as an introduction to object-oriented programming.

- Data Structures and Algorithms includes the design and implementation of linear structures, trees and graphs. Examples of common algorithmic paradigms, theoretical and empirical complexity analysis, and sorting, searching, and basic graph algorithms.
- Cybersecurity Principles provides an introduction to fundamental security design principles, programming flaws, malicious code, web and database security, cryptography algorithms and hashing functions; overview of computer networks and common network threat vectors.
- Computer Organization provides an introduction to computer system organization including performance, assembly language, machine-level data representation, arithmetic for computers, processor datapath control, memory, and input/output.
- Data Science includes data harvesting and cleaning; association rules, classification and clustering; analyze, manipulate, and visualize data using programming languages and probability and statistical modeling/inference to interpret large datasets (big data).
- For all these CS experiences, teachers will be required to develop lessons, activities, or projects associated with each CS topic.

Table 1. Computer Science Education Certificate Program – 18 Credits

Summer 1 (5 credits) (2 weeks)	**AY Quarterly (2 credits each) (7 weeks/quarter)**	**Summer 2 (5 credits) (2 weeks)**
Building a CS Learning Community of Practice (CoP) Program Philosophy & Requirements	Q1-Q4: Strengthening our CS CoP and Networks. Each quarterly course will emphasize CS pedagogy plus one of the CS content courses listed in Q1 through Q4 below.	Growing and supporting our CS CoP and Networks
CS Pedagogy - Planning instruction with problem-solving, project-based inquiry, culturally relevant teaching practices, current technology, verbal and written communication skills, effective management strategies, and appropriate instructional strategies (i.e. visual and active activities). Meets AOE Standards: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6	CS Pedagogy - Planning instruction with problem-solving, project-based inquiry, culturally relevant teaching practices, current technology, verbal and written communication skills, effective management strategies, and appropriate instructional strategies (i.e. visual and active activities). Meets AOE Standards: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6	CS Pedagogy - Planning instruction with problem-solving, project-based inquiry, culturally relevant teaching practices, current technology, verbal and written communication skills, effective management strategies, and appropriate instructional strategies (i.e. visual and active activities). Meets AOE Standards: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6
Web design Meets AOE CS Standards: 1.2.1, 1.3.1, 1.5.2, 1.5.3, 1.6.1, 1.7.1, 1.7.2, 1.7.3, 1.7.4, 1.7.6, 1.8.3 Intro to Programming Meets AOE CS Standards:	Q1: Discrete Structures standards have not been mapped for this course. Q2: Intermediate Programming Meets AOE CS Standards: 1.3.1, 1.4.1, 1.4.3, 1.6.1, 1.7.1, 1.7.2, 1.7.3, 1.7.4, 1.7.5, 1.7.6, 1.9	Intro to Data Science Meets AOE CS Standards: 1.6.1, 1.6.2, 1.8.1, 1.8.4 Computer Organization Meets AOE CS Standards: 1.2.1, 1.2.2, 1.4.1, 1.4.2, 1.4.3, 1.5.1, 1.5.3, 1.6.1, 1.6.2, 1.7.6

1.2.2, 1.3.1, 1.4.3, 1.6.1, 1.7.1, 1.7.3, 1.7.4	Q3: Data Structures & Algorithms Meets AOE CS Standards: 1.3.1, 1.4.2, 1.6.1, 1.7.1, 1.7.2, 1.7.3, 1.7.4, 1.7.5, 1.7.6 Q4: Cybersecurity Meets AOE CS Standards: 1.4.1, 1.5.1, 1.5.2, 1.5.3, 1.8.1, 1.8.5	Capstone Curriculum Project Meets AOE Standards: 1.2.1, 1.2.2, 1.8.1, 1.8.2, 1.8.3, 1.8.4, 1.8.5
AOE CS Standards: 1.2.1, 1.2.2, 1.3.1, 1.4.3, 1.5.2, 1.5.3, 1.6.1, 1.7.1, 1.7.2, 1.7.3, 1.7.4, 1.7.6, 1.8.3 2.1, 2.2, 2.3, 2.4, 2.5, 2.6	AOE CS Standards: 1.3.1, 1.4.1, 1.4.2, 1.4.3, 1.5.1, 1.5.2, 1.5.3, 1.6.1, 1.7.1, 1.7.2, 1.7.3, 1.7.4, 1.7.5, 1.7.6, 1.8.1, 1.8.5, 1.9 2.1, 2.2, 2.3, 2.4, 2.5, 2.6	AOE CS Standards 1.2.1, 1.2.2, 1.4.1, 1.4.2, 1.4.3, 1.5.1, 1.5.3, 1.6.1, 1.6.2, 1.7.6, 1.8.1, 1.8.2, 1.8.3, 1.8.4, 1.8.5 2.1, 2.2, 2.3, 2.4, 2.5, 2.6
CS Mentorship Experiences (optional)		
CS optional mentor experiences will be included as part of the certificate program and designed to offer all teachers options from which to choose to work with students in various informal CS learning contexts. This would be particularly advantageous for those teachers who have little to no CS teaching experience. Examples of possible mentorship experiences are described below. **1. FIRST Robotics** is a worldwide robotics competition that provides annual team-oriented design challenges and requires technically for its programs. Inviting teachers to build CS knowledge and skills by mentoring FIRST teams would provide them with the opportunity to develop technical skills, while simultaneously providing First teams with access to competent teachers as technical mentors. **2. Governor's Institute of Vermont (GIV)** is an annual program sponsored by the State of Vermont to offer interest-oriented summer programs to HS students such as GIV Engineering and Technology/ Design/Coding programs. GIV needs technically able instructors, project leaders and speakers to serve as mentors for the participating students and learn technical skills from GIV mentors and students. **3. Girls Who Code (GWC)** is a national nonprofit aimed at closing the gender gap in computing. Prior coding experience is not required to initiate a GWC club and teach coding concepts to grades 6-12 students. The GWC website contains many coding resources including access to webinar videos, lesson plans, and short bios of women in tech, and other resources that can be utilized in a club. GWC facilitators benefit from GWC resources and from teaching students who participate in the club. **4. Vermont STEMcorps LLC** places adult mentors that have professional experience and/or academic credentials in STEM-based fields with HS students. As a team, the student and mentor develop STEM-based solutions for local business clients. Vermont STEMcorps would support CSforALL-VT by offering opportunities for CS teachers to work as adult mentors in leading STEMcorps students to specify, develop, and deliver/deploy CS solutions on one or more projects.		

The CS certificate program will begin in Summer 1 with a two-week institute that introduces teachers to the program philosophy, requirements and framework including a focus on building a community of practice (CoP) (Lave & Wenger, Wenger, 2000). CS Pedagogy emphases will include problem-solving, project-based inquiry, culturally relevant teaching practices, current technology, verbal and written communication skills, effective management strategies, and appropriate instructional strategies (i.e. visual and active activities). Models of Project-based Inquiry (PBI) and Culturally Relevant Teaching (CRT) with an emphasis on equity literacy

(Gorski, 2016; Gorski & Pothini, 2014), will engage teachers in a continuous cycle of reflection, learning and action (Shulman, 1998). Through critical reflection and self-examination of prior knowledge, beliefs and biases (via pre and post content assessments, attitudinal surveys, case studies, and critical friends discussions) teachers will begin to recognize how their long-held beliefs about teaching, learning and students influence what and how they teach. Through these program experiences, the goal is for teachers to develop deeper levels of CS content and pedagogical practices that will ultimately change what and how they teach as well how they relate to and interact with all students in their classrooms.

A unique feature of the integration between CS content, PBI, and CRT is the reflective-teaching practices that all participants will engage in to not only examine instruction but also the historical, social, and ethical questions and impacts of CS on society today. In addition to problem-solving issues of diversity in the field of CS, participants will also utilize a variety of multimedia literacy to understand the origin of the field and the absence of diversity. These are important exercises to demonstrate the limitations of CS in a continually transforming global economy. The CS certificate will prepare participants to embrace ever changing technology literacies. The program will apply a fluid and intentional professional learning model to teach participants about equitable access for Computer Science in educational and professional settings.

Each of the institutes and courses will schedule in-class time for project work (keeping with the project-based framework) for teachers to collaborate on CS curriculum project requirements for the program including the integration of PBI and CRT into their developing computer science curriculum units. Focused time for journal reflection to consider the historical, social, and ethical questions and impacts of CS on society today as well as questions about CS content and other questions that arise for participants will also be integrated into program institutes and courses. Throughout the institute there will be opportunities for all participants to pilot/test/dialogue/revise/receive feedback about lesson ideas and drafts with the cohort. The summer institutes will be offered as a hybrid model with a blend of alternating in person, synchronous and asynchronous days over the 2 weeks with a fully remote option for those who request this option.

Quarterly courses offered online during the academic year will focus on integrating CS content and pedagogy into units on discrete structures, intermediate programming, data structures and algorithms and cybersecurity. A pedagogical format similar to Summer 1 described previously will be employed for all these quarterly courses. The Summer 2 institute will consist of a two-week program that reinforces the program's focus on CS concepts, community, problem-solving and culturally relevant pedagogy integrated into final CS content units on computer organization and data science. Again, a format similar to Summer 1 described previously will be employed for Summer 2.