# Computational Thinking for STEM Teacher Leadership Training at Louisiana State University

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***Abstract*—We developed and piloted a new course titled Computer Science Teaching Methods (CSM) in the fall semester of 2019. This course was based on materials developed from a previous program that trained high school teachers in computational thinking and programming through LSU's Cain Center. Pedagogical content knowledge informed the design of this course. Also, data gathered from teacher and instructor interaction at multiple sites during the summer STEM professional development program contributed to the courses' design. The CS Methods course targeted undergraduate computer science majors who were considering a career in teaching or who were interested in CS pedagogy. We encountered several challenges recruiting and retaining students and found that computer science students attracted to teaching careers do not fall into the stereotype of most computer science majors. Participation of women was higher than the average undergraduate CS courses. A disconnect appeared between the pedagogical practices promoted for teaching computing at the high school level and those being practiced at the college level. After learning about the 5E pedagogical model for teaching computing, students expressed interest in the potential of using more student-centered instruction, not only for high school instruction, but also for their own college courses. An area of disconnect also emerged in the programming formats, as all the students were comfortable with Java but all were unfamiliar with popular block-based programming platforms, such as Scratch. The transition from the CS curriculum taught in high schools to what follows in college needs to be smoother.**

*Keywords: computational thinking, computer science teachers, Research Practitioner Partnership*

## I. Introduction

In the fall of 2019, Louisiana State University (LSU) ran the first pilot of a new undergraduate course for computer science students interested in becoming K-12 educators. LSU is a UTeach replication site, and this course is intended to be the first one in a sequence to earn a teaching certification along with their CS undergraduate degree. Its design was informed by experiences gained in the LSU STEM Pathway's Summer Teacher Training Institute, which began in 2017. Teachers at the summer institute undergo a six-week intensive training in which they learn the content and pedagogy of a course in the Computing STEM pathway.

This course was not an isolated effort, but it is part of a Research-Practitioner Partnership (RPP) with a local school district. The RPP allows the student-teachers to observe, practice teaching, and receive mentoring from current in-service teachers who were trained at LSU's summer institute. Through the curriculum and RPP the teachers and pre-service student teachers bring computer science education to all the students in the district. Through the sharing of student data, lesson feedback, and observational pre-service teacher lesson execution, a feedback loop for course refinement is generated. The student outcomes are reviewed and the analysis is used to improve both the training of in-service and the pre-service teachers. This CS education model might also be of interest to researchers on equity and access in STEM education.

Although CS enrollment at LSU has almost doubled over the last five years, LSU's undergraduate STEM teacher preparation program (GeauxTeach) and LSU's four graduate programs for teachers did not offer an introductory computational thinking or programming course before the 2019-2020 academic year. The Computer Science Teaching Methods (CSM) was closely structured after the LSU Computing Pathways Program. The Computing Pathway provides high school students an opportunity to enroll in a series of elective project-based courses which lead to a career-tech diploma or to an enhanced university-prep diploma. LSU STEM Pathways Program has an introduction to computational thinking and programming course embedded in each of its four branches: Pre-Engineering, Digital Design and Emergent Media, Computing, and Biomedical Sciences. The pathways are designed

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to provide high school students with a background in CS. An area of critical shortage in our state has been the supply of teachers with training in CS and specialized STEM discipline, like engineering. Very few computer science teachers graduated from Louisiana universities in recent years [1]. The development of the CSM course is a first step in creating a CS teacher certification program at LSU.

## II. Computer Science Teaching Methods Course

The course covers four units: (1) pedagogical content knowledge for secondary CS; (2) the 5Es pedagogical model; (3) self-paced learning and teaching of an introductory high-school course; and (4) a field teaching experience, which is by no means exhaustive, given that the area of K-12 CS pedagogy has many topics to investigate [2], [3].

In the first unit, we covered the seven big ideas from the AP Computer Science Principles framework, as well as standards and guidelines for teaching CS, and specific high school professional practices, such as managing students' classroom use of computers, strategies for fostering student collaboration, and techniques for maintaining student productivity.

The second unit is focused on the 5E instructional model. This was selected to align the CSM with the current structure of LSU's GeauxTeach program.

The third unit placed the college students into a hands-on learning approach to the abridged Introduction to Computational Thinking (ICT) high school curriculum. ICT is focused on the concepts of programming with mathematical connections to Algebra 1, in which most of the state's ninth graders are concurrently enrolled. The undergraduate students began preparing to teach by creating a lesson to teach to their fellow classmates. Each lesson was then peer reviewed.

The final unit focused on a pre-service field teaching experience. Students attended a local high school and observed a classroom for two days. Then they prepared a lesson from ICT and spent three class days teaching it to the classes they had previously observed.

## III. Qualitative Research Study

Five CS majors with no prior teaching experience, lesson planning, or learning theory instruction completed the course. Two of five (40%) students were female. The course instructor is a computer scientist and course developer with multiple years of experience teaching high school CS courses. We conducted a post-course research study that sought to understand students' attitude and opinions on the course. We distributed an online survey, and conducted individual interviews with ten questions centered around three broad research questions:

1) How do CS undergraduate students describe the similarities and/or differences between the CSM course and other undergraduate CS courses?
2) How do CS undergraduates describe their learning of CSM after completing the CSM course?
3) How do CS undergraduate students describe their experience with the 5Es instructional model after completing the CSM course?

We transcribed interview data to text, imported the text into a qualitative coding platform and distributed out to researchers for individualized coding. We coded each response to accurately reflect the attitude and opinion of the interviewees. Following coding, responses were merged to help identify broad patterns and overarching themes. We will use the data to inform quality improvements of the course.

Four of the five students liked the course. Three of five found the course useful. All students reported their field teaching experience as the accomplishment they were most proud of. All but one student saw the course as valuable. Most students reported the amount of course work was higher than other CS courses. Four of five students believed that they gained skills in teaching, lesson planning, and time management. Adapting to the 5Es instructional model, in contrast with traditional, lecture-based CS courses, was viewed as a challenge.

The 5Es instructional model was novel to both the CSM instructor and the students accustomed to traditional lecture-based formats. At LSU upper-level-undergraduate CS courses tend to be large (50 or more students) and students passively listen to the instructor lecture. The CSM classes were taught using the 5E model. The students reported that the student-centered, high participation format of 5E model was unfamiliar and at times disconcerting. Student overall feedback reported positive experiences with 5Es Engagement, the first phase, aimed at quickly provoking learners' interest. However, frustration ensued during Exploration, the second phase, because coding nuances necessary for meaningful exploration go missing unless the instructor slightly modifies 5Es to include scaffolding with starter code.

## IV. Conclusion

With the growing STEM economy and demand for computer-capable citizens, school districts are exploring innovative curricular approaches. However, the critical shortage of educators with STEM training severely limits statewide access. University-based teacher preparation programs have a critical role to play in reversing this situation by offering computational thinking and programming content and pedagogy courses for all candidates, and setting appropriate participation expectations for program completion. Programs to certify STEM majors, and in particular CS majors, might need to emphasize the merits of a student-centric pedagogy which most students have not experience in their secondary or post-secondary education. The new course proposed here is the first step towards fulfilling the needs of pre-service K-12 teachers to prepare the next generation of computing literate citizens.

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