Creating a School-wide CS/CT-focused STEM Ecosystem to Address Access Barriers

Danielle Boulden
NC State University
Raleigh, NC, USA
dmboulde@ncsu.edu

Callie Edwards
NC State University
Raleigh, NC, USA
callie_edwards@ncsu.edu

Veronica Cateté
NC State University
Raleigh, NC, USA
vmcatete@ncsu.edu

Nick Lytle
NC State University
Raleigh, NC, USA
nalytle@ncsu.edu

Tiffany Barnes
NC State University
Raleigh, NC, USA
tmbarnes@ncsu.edu

Eric N. Wiebe
NC State University
Raleigh, NC, USA
wiebe@ncsu.edu

Dave Frye
NC State University
Raleigh, NC, USA
dafrye@ncsu.edu

***Abstract*—STEM ecosystem is an emerging model for identifying the barriers and support structures that students have in their learning trajectories in STEM. In this paper our university-based research team presents a CS/CT-focused STEM ecosystem strategy designed to address underrepresentation in computing fields. W e d escribe o ur c urrent a nd f uture w ork w ithin our school-level research-practice partnership (RPP) with a local middle school, used to guide the creation of this ecosystem.**

***Keywords*—Research-Practice Partnership, K-12, STEM Ecosystem**

I. Introduction

Large segments of the U.S. population (e.g., women, African-Americans, Hispanic/Latinx), have been historically marginalized from participation in computationally-intensive STEM professions and in the higher education degree programs that prepare them for those careers [1]. Efforts to broaden participation in these fields a re a c ritical strategy to expand and diversify the talent pool to meet the waxing demand for STEM-trained professionals.

Policy makers have recently charged organizations who play an important role in preK-12 STEM education with addressing this issue by both helping to better understand its root causes and developing innovative strategies to address it [2]. Informed by these concerns we are establishing a computer science and computational thinking (CS/CT) focused STEM ecosystem that is cultivated and sustained through an existing Research-Practice Partnership (RPP) at a middle school with high racial/ethnic diversity to address and research the challenge of broadening participation in CS focused academic programs.

The STEM ecosystem framework has emerged as a powerful strategy for addressing STEM literacy and education [3]. It is founded upon the understanding that building student capacity and interest in STEM-focused academic activities needs to be addressed in a systematic and coordinated fashion over time and place [4]. At the core of a STEM ecosystem, are multiple opportunities for learners to engage in a variety of activities across diverse settings that enable them to develop knowledge, interest, and skills in STEM disciplines over the course of their youth [5], [6]. Students interact with other individuals (e.g., peers, mentors, teachers, parents) throughout these experiences subsequently influencing their academic and career trajectories in, hopefully, positive ways [5]. Learning can occur across multiple settings including the formal school environment as well as out-of-school learning opportunities such as after school clubs, summer camps, and informal home experiences [6]. When strategically aligned and coordinated, these opportunities become intentionally designed pathways to support equitable STEM learning experiences for all students. Universities, schools, businesses, and community organizations are all integral stakeholders as they provide critical resources for authentic STEM learning [7].

II. EcoCS: Building a CS/CT-focused Ecosystem through a school-level RPP

Our team views the STEM ecosystem as a robust framework for addressing the barriers and necessary support structures that students encounter within their learning trajectories in STEM areas, including CS/CT. Therefore, we posit that a CS/CT-focused STEM ecosystem can be a viable strategy to broaden the participation of student populations that have been historically denied access to meaningful CS/CT learning opportunities and to position them for success along such a CS/CT learning trajectory.

Our model recognizes that effective CS/CT learning requires coordinated efforts amongst school leadership, teachers, parents, and other key external constituencies as they work to design and support computationally-rich educational pathways for all students. Current research and policy initiatives recognize that computationally rich experiences can occur not only across formal STEM subject areas, but also in non-STEM coursework, elective courses, and informal educational activities [8]. Outcomes of this coordinated effort will produce

This work has been funded in part by NSF Grant No 1837439

978-1-7281-7172-2/20$31.00 ©2020 IEEE

teacher and student resources, robust CS/CT learning opportunities, and adequate training that prepares all stakeholders to broker opportunities directly and indirectly as students grow their capacity and interest.

Our strategy incorporates a breadth and depth approach in which breadth refers to exposing the entire, diverse student body to culturally responsive CS/CT learning experiences through introductory CS/CT-related activities in core academic classes (e.g., mathematics, science). Additionally, this broad exposure to CS/CT, starting in 6th grade, means building a critical mass of experiences that students can share with their school peers and build motivation and expertise, accelerating student preparation for later CS/CT opportunities. Furthermore, intentional outreach to students' homes and community are provided by the school to expose parents, guardians, and siblings to CS/CT activities and help bolster support for student interest outside of school. Breadth is then coupled with opportunities for students to deepen their interest through additional learning endeavors that build their capacity for success in high school and beyond.

To help realize the potential value of a CS/CT ecosystem, our research team partnered with practitioner leaders at a local middle school with a digital sciences magnet theme to operationalize this model. Using an RPP approach, research and practitioners collectively identified a problem of practice, namely how do we broaden participation of underrepresented populations in CS/CT through its integration into various elements of the academic enterprise. Then, RPP team members developed and iteratively refined strategies to address this challenge.

III. Progress to date and future directions

Since the inception of this RPP, university researchers and practitioner leaders from the local middle school have engaged in several collective efforts to infuse CT practices into the school culture. The first major initiative was the establishment of a digital sciences team (DST) during the 2018-2019 academic year. The DST is tasked with leading efforts to integrate digital sciences and CT throughout the school. The team is comprised of researchers, school leaders, and a representative from each subject area. The team reviews and plans programs and activities for students and parents.

Researchers also collaborated with the school's leadership to assemble a teacher leader cohort charged with leading CT and CS integration efforts including school-wide professional development (PD). To become teacher leaders, these individuals were required to attend a weeklong summer training on infusing computing. In order to build the content and pedagogical knowledge of other teachers within the school, the cohort holds monthly PD sessions during their subject-area planning times. The teachers then offer follow-up support to their peers as needed.

University researchers also provide direct support to teachers as they co-develop curricular units and implement them within their classrooms. To date, all students have engaged in CS practices within their science classrooms to learn important content standards through computational modeling. Last year, the research team collaborated with all science teachers to develop and implement curricular units that provided students with achievable and relevant opportunities to use, modify, and create their own computational models to simulate scientific concepts.

Importantly, effective communication and trusting relationships facilitate the development and maintenance of productive RPPs. As such, researchers have dedicated considerable time and resources to designing systems that foster regular communication and rapport building with school leadership and staff in an effort to increase buy-in and knowledge about creating a school-wide CS/CT-focused ecosystem. Members of the RPP team engage in bi-weekly meetings to review and resolve teacher issues, and research-practitioner duos attend professional meetings to deepened their understanding about navigating a RPP. Notably, the team also hosted a research-practice partnership kick off meeting to inform all school staff of the current and future work at the beginning of the 2019-20 academic year. Through this deep and consistent dialogue, the team builds a common understanding of vision, problems of practice, and metrics of success. Finally, the ecosystem work also extends to families and parents as the RPP team co-plans and supports several outreach events and activities such as curriculum showcase nights, school-wide magnet fairs, and a family code night at the school.

Now that we have established the trust and respect of school leadership, we are planning more intensive and focused data collection and analysis. These efforts will enable us to study barriers to developing an ecosystem that supports CS/CT for every student, factors or interventions needed to support that development, indicators of success, and an understanding of how the ecosystem prepares and engages all students for future CS/CT work beyond middle school. Data collection and analysis will be iterative as new insights emerge about new factors pertinent to the ecosystem. Our overarching goal is to generate new knowledge about how to grow STEM ecosystems that support CS/CT learning for ***all*** students.

References

[1] J. Margolis, R. Estrella, J. Goode, J. J. Holme, and K. Nao, *Stuck in the shallow end: Education, race, and computing*. Cambridge, MA: MIT Press, 2008.

[2] A. Powell, N. Nielsen, M. Butler, M., C. Buxton, C., O. Johnson, L. Ketterlin-Geller, and C. McCulloch, *Creating Inclusive PreK–12 STEM Learning Environments*. Waltham, MA: EDC, 2018.

[3] STEM Funders Network, "STEM Learning Ecosystems," *STEM Funders Network*, 2018. [Online]. Available: http://stemecosystems.org. [Accessed September 14, 2019].

[4] W. R. Penuel, T. L. Clark, and B. Bevan, B., "Infrastructures to Support Equitable STEM learning across settings," *Afterschool Matters*, vol. 24, pp. 12-20, 2016.

[5] National Research Council, *Identifying and supporting productive STEM programs in out-of-school settings*. Washington, D.C.: The National Academies Press, 2015.

[6] K. Traphagen, and S. Traill, *How cross-sector collaborations are advancing STEM learning*. Los Altos, CA: Noyce Foundation, 2014.

[7] A. J. Levy, E. Fields, J. DeLisi, L. Winfield, J. Louie, and G. Fitzhugh, "Office of Science and Technology Policy–State-Federal STEM Summit," Education Development Center, June, 2018.

[8] Y. B. Kafai, and Q. Burke, "Computer Programming Goes Back to School," *Phi Delta Kappan*, vol. 95 no. 1, pp. 61–65, 2013.