Discovering Computer Science: A High School CS Course Co-developed by College & High School Teachers

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ABSTRACT

We present a new high school level computer science (CS) curriculum that is a key component of a comprehensive college/high school partnerships program supporting secondary CS education in New York State. The year-long curriculum offers a broad introduction to CS and is designed using best practices for promoting diversity, equity, and inclusion. It was collaboratively designed and implemented by a team of college CS faculty and high school CS teachers participating in a research-practice partnership. This year (AY2023-2024) the curriculum is being taught in 27 school districts representing high-needs, rural, and suburban communities. Preliminary analysis of student data is included.

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1 INTRODUCTION

Discovering Computer Science (DCS) was developed as a foundational high school level course for all students that promotes diversity, equity, and inclusion. The year-long course draws from established national curricula and resources such as The Beauty and Joy Of Computing [5], Exploring CS [6], and CS UnPlugged [1]. It extends and adapts these materials to fit the state context. The course covers the history, principles, and transformative applications of computer science and includes a comprehensive introduction to programming. Students start by programming in Netsblox, a friendly graphical language that allows them to express themselves by creating interactive games, animations, and stories, while learning the fundamentals of computer programming. Students continue to develop their programming and problem solving skills using the text-based language Python. Finally, students learn how to design their own websites using HTML, CSS, and JavaScript. Weaved throughout the course are projects and activities on the societal impacts of computing. The course meets all of the CSTA and NYS 9-12 CS Learning Standards [3, 8].

The DCS curriculum was developed and implemented collaboratively by college faculty and high school teachers as an important component of a multi-faceted National Science Foundation grant [1] project. The project was designed to increase the number and diversity of students taking high school CS courses by building CS teacher capacity through comprehensive college/high school partnerships. Most of the new CS teachers in the program had little or no formal CS background and were certified in other areas. The DCS course has been a good first course for new CS teachers to offer. They gain confidence and then often move to teaching more advanced dual-enrollment CS courses.

The college faculty developed the first iteration of the DCS course in AY2019-2020 with regular feedback from teachers' classroom experiences. When the COVID pandemic resulted in schools going remote in the Spring of 2020, a core group of three high school CS teachers, two undergraduate CS/Education majors, and a college CS faculty adapted the curriculum for the remote learning that took place in the AY2020-2021 school year. The adapted curriculum was good for remote learning and continues to be effective in-person as well. The most recent round of curriculum improvements has focused on alignment with the new NYS CS Learning Standards [8].

The DCS course is supported by a summer and school year equity focused professional development (PD) program and a vibrant professional learning community. In its first year (AY2019-2020), DCS was offered in six school districts. This year (AY2023-2024) it is being taught in 27 districts; 12 are rural and 11 are high-needs.

2 FIVE VALUABLE COMPONENTS

Here we describe five components of the DCS curriculum that are fundamental to its goals of being a course for all students that promotes diversity, equity, and inclusion and develops a sense of belonging and confidence in the CS classroom.

Spiral Curriculum: Three of the four main units of DCS focus on the development of a strong foundation in computer programming. These units are block-based programming, Python programming,

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and web programming. In each unit, students study the same foundational programming concepts: statements, variables, math and logic, conditions, loops, and functions. Each unit is broken into activities and laboratory exercises that include increasing levels of dificulty and leverage previous knowledge and learning. Each unit includes at least one open–ended culminating project that invites students to showcase what they have learned. The fourth unit of the course focuses on the impacts of computing, starting with the student's individual voice and experience and growing toward their community and the larger society.

Reflective Learning: Throughout the course, students practice reflective learning. Each laboratory and project ends with an entry into the student's Google Site portfolio. Students use their portfolio to highlight key aspects of their work and to reflect on their learning by recording responses to guided questions. Teachers use the portfolios to gain insight into student learning and build a relationship with the student that reaches beyond the curriculum. Together with the students, teachers share particular entries with parents, prospective students, guidance counselors, and administrators.

Diversity, Equity, Inclusion: Teachers have students in the same classroom that differ by grade level, prior computing experience, gender, ethnicity, cultural identities, and learning strengths and challenges. To this end, teachers are supported with ongoing professional development that centers on the DCS Core Values, which include developing a growth mindset, employing equity-based and culturally responsive teaching practices, and utilizing inquiry-based learning techniques The curriculum includes activities for students that afirm their values, celebrate their cultural identities, and invite collaboration and personal expression. Students also participate in a week-long project where they identify issues related to diversity and see others like them having success in the field.

Differentiated Instruction: The DCS curriculum was developed using Universal Design for Learning [2] strategies to provide the best opportunity for every student to have a high quality experience in the course that challenges them appropriately and helps them learn and grow. Examples of strategies included in the curriculum are the use of multiple media, scaffolded labs and activities that include "bells and whistles" activities for more advanced students, and fostering open communication in a collaborative learning environment. Teachers learn and develop effective strategies for productive use of pair programming, fostering a safe and supportive learning environment, and customizing lessons to meet student needs.

Stakeholder Involvement: We provide teachers with guidance and resources around student recruitment and equity in CS via the CAPE model [4]. However, we recognize that teachers alone cannot realize the goal of providing an equitable and inclusive high-quality CS education for every student. That is why we have begun working to involve school guidance counselors and administrators in developing an effective CS education culture in their district. We are also facilitating the exchange of ideas among districts through multi-district meetings and conference presentations.

3 DCS STUDENT DATA

Preliminary analysis of 304 matched pre/post DCS student surveys between 2019 and 2022 showed that student perceptions of their CS skills increased over the course of the school year with high statistical significance ($p < .001$). Student indicators of a sense of belonging in the CS classroom (e.g. felt valued and welcomed) on post-surveys were also high. Table 1 shows example statements and mean student responses. Students rated their level of agreement with the statements on a 1-5 Likert scale where 1 = "strongly disagree" and 5 = "strongly agree", with 3 = "neither agree or disagree". However, student interest in pursuing CS in the future had little to no change from the pre- to post-surveys. Interviews conducted with female DCS students suggested that having a caring female teacher helped female students feel a greater sense of belonging in the classroom where they were a minority. One female student said, "[my teacher] she's so understanding and helpful... And I think that that is one of the reasons why I'm continuing it." The student also appreciated how the DCS course helped her better understand the role of a computer scientist, but she wanted to know much more about daily life in the field before making any future career decisions. While there is a need for additional research on factors influencing students' interest in careers in CS, the data from this study show that quality experiences in one introductory CS course did not lead to statistically significant increases in students' interest in pursuing additional CS opportunities, a challenge also noted in other studies [7, 9]. However, students did develop confidence in their computer science skills and were likely able to make more informed decisions about their future pathways in computer science.

Table 1: Example post-survey results.

Statement	Mean
The teacher for this course made me feel welcomed in this class.	4.39
The teacher for this course encouraged my participation in the class.	4.30
I felt my opinions were valued in this class.	3.84
Overall, I was satisfied with my experience in this class.	4.05

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