Promulgating Computer Science in High School Education

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Abstract

The State of North Dakota is responding to the growing need for K-12 education in computer science. With the aid of Google funding and in cooperation with the North Dakota Department of Public Instruction, North Dakota EduTech, and the NDSU School of Education, we are in the process of developing a certificate program for in-service high school teachers in North Dakota to teach computer science. This certificate program is designed to fit the structure of the Master of Education (M.Ed.) program at NDSU, which also benefits pre-service teachers.

Introduction

In December of 2018, the North Dakota Department of Public Instruction (NDDPI), under the direction of Superintendent Kirsten Baesler, convened a panel of experts called the Computer and Cyber Science Standards Review Committee. This group was assembled to develop the first ever set of Computer and Cyber Science (CCS) standards. These standards, finalized, approved and adopted on Thursday, March 7, 2019, will guide the development of computer science curriculum across the entire public school range, PreK-12. To prepare for the meeting, a draft copy of the proposed North Dakota State Academic Content Standards in Computer and Cyber Science was circulated for review and a final version was published online ("Content Standards," 2018).

This initiative followed from a successful event held at Bismarck State College during the summer of 2018, where a group of teachers and administrators gathered for a 4-day workshop billed as the Cyber Teachers Summer Seminar ("CTSS," 2018). The workshop came about through an arrangement where North Dakota EduTech (http://www.edutech.nodak.edu/) partnered with Bismarck State College and the National Integrated Cyber Education Research Center (NICERC, https://nicerc.org/) to introduce middle and high school teachers to the issues involved with teaching computer science.

Additionally, in response to the national priority given to the concept of "computational thinking" (Wing, 2006), and U.S. Department of Commerce predictions of a shortage of trained Information Technology workers and teachers needed to train them, the Department of Computer Science at North Dakota State University (NDSU) designed and began implementation of a new graduate certificate program in Computer Science Education aimed at training teachers to teach computer science.

The Cyber Teachers Summer Seminar and the Google Grant

In an effort to gauge in-service teacher interest in a certificate program, we successfully coordinated with EduTech during the summer of 2018 to assist with the CTSS. The seminar ran July 30-Aug 2 at Bismarck State College. Attendees were from 30 school districts across the state of North Dakota, with both middle and high school teachers present. Teachers were reimbursed for registration and provided a stipend for the seminar through a Google grant ("Google," 2018). As part of the seminar, teachers completed a survey designed to explore what they felt they needed to support their own education in computer science. The survey shows a wide variety in wants and needs from the participants of the summer seminar; some highlights include:

- Over 80% of the teachers indicated their students had either daily or weekly access to the internet while at school to complete class work.
- About 90% of attendees indicated their students had daily or weekly access to computers in the school to complete class work.
- 22% of the attendees currently teach a computer science class in programming, web design, or problem solving. The remaining attendees are interested in teaching

computer science but come from different backgrounds and do not feel prepared to do so at this time.
- The survey shows that over 85% of summer seminar attendees feel digital citizenship, cyber security, search algorithms, and programming/recipes are areas where they need more training in order to teach computer science effectively.
- Over half of the teachers indicated they would complete an 18-credit certificate course to learn more about teaching computer science.

Accomplishments so far include receiving approval for the 18-credit program (6 graduate courses) from the North Dakota State Board of Higher Education (SBHE), developing the first course in the sequence, and ongoing efforts to develop a Community of Practice using the Microsoft Team platform in the NDDPI Office 365 instance.

The NDSU Graduate Certificate on Computer Science Education

This certificate is primarily aimed at high school teachers in need of credentials to teach "dual credit" courses in their schools as well as AP Computer Science instructors. To meet the needs of the program the courses must be (1) online; (2) taught in the summer; and (3) taught in a condensed or hybrid format.

The graduate certificate in Computer Science Education comprises six 3-credit courses, for a total requirement of eighteen credits, aimed at preparing in-service teachers for teaching high school computer science. The certificate program will be offered online. The courses are selected for their content which covers just the essential, core concepts of introductory computer science.

As part of the Graduate Certificate Program and in keeping with best practices in education, students will prepare a “Digital Portfolio” with artifacts of accomplishment that is shareable and organized for final presentation. This Digital Portfolio will document the information necessary to teach any Computer Science course needed at the high school level. Artifacts will be added to the portfolio after the completion of each course.

Program Objectives:

The Computer Science Education Graduate Certificate Program offers the following characteristics:

1. Focus on fundamental topics providing a broad background in Computer Science.
2. Flexibility to allow students from varied backgrounds and different points in their working career to enter the program with a minimum of pre-requisite work.
3. Flexibility to allow students currently pursuing advanced degrees in computing related disciplines to join the program and readily add the Graduate Certificate to their credentials.

4. Provide the necessary 18 credit hours for high school teaching credentials while presenting a course offering schedule to allow students to complete the program in fifteen months.
5. Make maximum use of existing department resources at NDSU to support delivery of the program.
6. Gain a broad background and knowledge in Computer Science Education through a fixed set of core courses.

The NDSU Seminar on Computer Science Education

In parallel with the Google funded project aimed at building a Computer Science Educator Community of Practice, the Department of Computer Science is currently offering a 1-credit graduate research seminar, CSci 790: Seminar on Computer Science Education. This group meets weekly to discuss research papers in the recent literature.

One recent example described a project undertaken in Cyprus comparing the learning rates and attitudes towards computer science of a group of 181 students divided into five groups: beginners, games, robotics, SQL and Arduino (Paspallis et al., 2018). This study showed that "learn by doing" activities such as games and robotics are the most positively rated by students in middle and high school.

Another very interesting paper described the issues with building a community of practice among in-service computer science educators.

Issues with Building a Community of Practice

There are similarities in the NDDPI consideration of the state of computer science education in North Dakota public schools and other localities around the world. In Sweden, for example, a research group from Linköping University was funded by the Swedish Department of Education (Skolverket) to study a model for bringing computer science education (focusing on computational thinking) to all students in K-12. Heintz and Mannila (2018) state that although the need for teaching computer science to students was clear, the matter of how to motivate and train the in-service teachers to learn how to teach computer science remained a challenge. Their study included a pilot project, where ten teachers from K-9 schools were selected by administration to attend three 3-hour workshops administered by the authors. The goal of these workshops was for the ten teachers to create and execute three activities related to computational thinking with their students over the course of a semester. The results of the pilot study were generally positive, but the training did not motivate the teachers to do any additional lessons related to computational thinking. Further results from the students indicated overall positive responses and a higher engagement of quieter/reserved students in the activities (Heintz & Mannila, 2018).

The next step in the study was to try motivating teachers to consider computational thinking in more exercises and activities in their classes. The project included one teacher from each of the fifty K-9 schools in the district and asked them to participate in three half-day workshops per semester, over two years. Scaffolded content was delivered during the workshops, including an introduction to computational thinking, assessing activities, introduction to CS programs (Bebras, Hour of Code, Scratch), and working with Python, algorithms, and micro:bit. Each workshop included various discussions on each of these topics, pedagogical concerns, and how these topics fit into the curriculum. Teachers were also encouraged to focus on spreading this content to other teachers in their schools. Outcomes from this study were twofold; there were direct results of the study that pertained to creation of suitable activities, positive feedback from teachers and students, and number of students participating in the project. There were also indirect results that were more systemic, such as communication issues and problems with administrative support and leadership at the district level.

The results from this study are pertinent for our discussion of computer science education here in North Dakota. Heintz and Mannila (2018) observed that they lacked understanding of how "school administration works." They structured the project so teachers would receive all communication from the authors through an administrative contact at the district level. The authors failed to recognize that personnel changes occur often in school districts, even from semester to semester, and thus a lack of continuity affected the project. Further, teachers themselves were transferred between schools, and this also resulted in lost time to recruit new teachers and bring everyone up to speed when this occurred.

Another outcome from the study was the discovery that teachers teaching teachers proved difficult; most of the teachers who participated in the study did not spend time teaching the concepts to other teachers in their schools. However, the good news from this study is that the teachers who participated felt prepared by the workshop trainings, suggesting that good teacher training was possible with modest effort and that getting teachers to actively teach computer science was possible (Heintz & Mannila, 2018). Furthermore, the teachers felt confident adapting lessons to their content (teachers were not necessarily from math or science disciplines), although teachers noted that it was very difficult to move from learning and teaching *programming concepts* to learning and teaching *programming*.

Conclusions and Future Work

The Department of Computer Science at NDSU is establishing a Computer Science Education Graduate Certificate Program for in-service high school teachers to learn material necessary to teach AP Computer Science. We are encouraged by initial survey results from the 2018 Cyber Teacher Summer Seminar where over half the participants showed interest in the Certificate Program. The Certificate Program will focus on providing the fundamentals of computer science and computational thinking content presented in an online setting that is available when working teachers can commit to the courses. Based on the computer science literature, (e.g., Ryoo et al., 2015, Yadav et al., 2016, Hamlin et al., 2018, Heintz & Mannila, 2018), we understand the value of scaffolding

content to improve the connection from programming concepts to actual programming and to provide teachers with a way of staying connected through a dedicated community of practice.

Future work includes completing the next phase of courses for the Certificate Program following best practices guidelines for creating online courses (Gulatee & Combes, 2006). We are undertaking an ongoing effort to establish a foundation for a community of practice through the "Computer Science Educators" team on the Microsoft Teams NDDPI instance of Office 365. It is our plan that this portal will eventually become rich with resources, hints and pointers, shared lesson plans and other ancillary materials, both provided by us, and by the community of practice as it grows and thrives.

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