A Regional Professional Development Program for Computing Teachers: the Disciplinary Commons for Computing Educators

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Abstract: Computer science is a relatively young but important discipline in both secondary and post-secondary education. This paper describes the design and preliminary implementation of a regional teacher professional development program for computing teachers: the Disciplinary Commons for Computing Educators (DCCE). The main goal of DCCE is to build a vibrant community of computing teachers, where teachers could actively share and investigate their own teaching practices, get exposed to diverse forms of practice and gain confidence and knowledge about teaching computing courses. We start with presenting some unique challenges to computing teacher education and explaining the rationales for the design of the DCCE program addressing some of those challenges. Then, we describe the methods and preliminary results from the implementation of the first year pilot DCCE cohort. Overall, this project is dedicated to exploring potential ways of supporting in-service computing teachers.

Description of the Program

The Problem and Objectives

Computer science education (more broadly called computing education) is critical in both secondary and post-secondary systems, which, in a variety of ways, can contribute to the intellectual development of students, the innovation potential of other scientific disciplines, as well as the economic well being of countries (Ericson, et al., 2008; Shackelford, 2005). However, computer science (CS) is a relatively young discipline in K-12 education. CS educators and researchers are facing unique challenges, including teacher related issues such as the recruitment of computing teachers, pre-service computing teacher preparation and in-service teachers' professional development. First of all, as the Computer Science Teachers Association (CSTA) reports (Ericson, et al., 2008), we are facing a crisis in CS teacher certification. There is a significant lack of consistency in CS teacher certification standards in the US. In many states, a CS teaching certificate is not required in order to teach computing courses (Khoury, 2007). Thus, teachers with little or no CS training are frequently assigned to teach computing courses. Meanwhile, in some states, since new computing teachers cannot be certified as computing teachers due to the lack of certification programs for computing education, they must meet the certification requirements in some other discipline, in which they might not actually wish to teach.

Furthermore, the evolving nature of the computing field also brings big challenges to computing teacher education. Although there have been efforts and progress in developing a model curriculum for K-12 CS (Tucker, et al., 2006), there is still much confusion about CS in K-12 education. Computing teachers have to deal with multiple challenges related to curriculum standards, varied programming languages, updated disciplinary knowledge, teaching methods, maintaining student interest, etc. For instance, the field of CS has its own problems in coming to an agreement for defining this field (Denning, 2005, 2009). The ACM Model Curriculum for K-12 Computer Science (Tucker, 2006) provides a useful definition of computer science for high school (HS) educators, seeing CS as "the study of computers and algorithmic processes including their principles, their hardware and software design, their applications, and their impact on society." However, among those not familiar with the discipline, there is still a tendency to confuse the study of computer science as a scientific discipline with other uses of computing technology within education, particularly computing literacy (the mastery of basic software applications), keyboarding, or educational technology (Ericson, et al., 2008). As a result, many policy-makers, administrators, and even computing teachers are failing to provide students with access to the key academic discipline of computer science. Secondly, from the CSTA National Secondary Computer Science Survey, the greatest challenge teachers are facing in teaching computing is still the rapidly changing technology (CSTA, 2009). Teachers have to update their CS content knowledge and related technology used in teaching CS. Similarly, due to the short history of computing education in K-12, not much is known about the best teaching practices for computing. Moreover, since there are so few computing teachers, these teachers are especially isolated, where often there is no one else in their buildings, or even in their school districts, to ask for support in the content or pedagogy for teaching computing. Therefore, in addition to teacher preparation, there is a great need for continual support and professional development for in-service computing teachers.

In this paper, we describe the design and preliminary implementation of a teacher professional development effort, the Disciplinary Commons for Computing Educators (DCCE). To address the issue of CS teacher isolation and the need of continual professional development for in-service CS teachers, DCCE is dedicated to fostering computing teachers within a regional community of computing educators. Particularly, we focus on introductory CS teachers in a local state. The DCCE project invites high school (HS) computing teachers, especially Computer Science Advanced Placement (CS AP) teachers along with college faculty who also teach introductory CS courses. In particular, as a pilot teacher cohort, the first year DCCE program uses action research as a strategy of professional development, which creates opportunities for teachers to share, examine and reflect on their own teaching practices. Through collaborative action research and cross-level communication within the local community of computing educators, DCCE is dedicated to building a vibrant community of computing teachers, where teachers actively share and investigate their own teaching practices, get exposed to better forms of practice and gain confidence and knowledge about teaching computing.

The DCCE Program

DCCE is an NSF funded three-year project. Each year, a cohort of HS and university computing teachers meet on Saturdays monthly to share practices and conduct brief action research projects. Table 1 describes the meeting agendas for the first DCCE teacher cohort in 2008-2009 academic year. The agenda for each meeting was participant-driven in terms of choosing discussion topics, defining action research project ideas and coordinating project process. During the first DCCE teacher cohort, three researchers worked together as leaders to plan and organize the meetings and to offer support for teachers' action research projects. At the end of the year, two participating teachers volunteered to be the leaders for the second year's group with new participants. We plan to repeat the cycle three times, with each previous cohort invited to participate in an online social network, in order to create a community of computing teachers across the state.

Table 1: First year's DCCE meeting agendas

Date	Topic	Homework
January 10, 2009	Welcome and Introduction; Challenges and Concerns for Computing Educators; Lessons from Computing Education Research	Reflection on Current Teaching; Ideas for Action Research Projects
February 7, 2009	Participant-led Discussion: Computing Curriculum in HS and College; Project Examples & Research Methods; Project #1 Group Forming and Planning	Project #1 Data Collection
March 14, 2009	Project #1 Data Analysis and Reflection; Project #2 Idea Brainstorming	Ideas for Project #2
April 18, 2009	Participant-led Discussion: IT Curriculum; Project #2 Design and Plan	Project #2 Data Collection
May 16, 2009	Participant-led discussion: HS Extra Curricula Activities; Project #2 Analysis and Reflection	Project #2 Data Collection (Continued)
June 6, 2009	Participant-led Discussion: Pair programming[1]; Project #2 Report and Reflection (Continue); DCCE Project Reflection and Evaluation	Participation in DCCE Project Evaluation (Surveys and Interviews)

In the first DCCE teacher cohort, participants were prompted to reflect on their current teaching by asking the challenges and concerns they were facing. Due to the difficulty of identifying specific research questions and the lack of research experience, the participants were unable to determine an action research project at the beginning. Therefore, the research team provided a list of research questions asking the teachers to select the one most interesting to them. Two groups were formed for the first action projects: one group worked on students' attitude to programming, and the other group investigated the predictors of student success. The research team also modeled the research process, providing scaffolding in the process of developing instruments, collecting data and analyzing data. The participants decided to conduct the second action research project focusing on program (code) comprehension[2]. The participants worked together in forming the research question,

[1] Pair programming is a technique in which two programmers work together at one work station. One types in code while the other reviews each line of code as it is typed in. When applied in CS courses, typically, two students work collaboratively on the same algorithm, design or programming assignment.

[2] Code comprehension is an important learning goal in programming courses. Students are not only expected to learn how to write a program, they are also expected to be able to read and understand an existing program/code.

developing code comprehension questions, and then ran the test in every school. They then came back to the DCCE meetings, graded the students' responses together, discussed the results, and reflected on the implications of the findings for their own teaching.

Theoretical Framework

Although there is limited research specifically addressing the professional development of computing teachers, there is an enormous body of research about the design and delivery of teacher education programs, offering insights that inform the design of the DCCE program. In particular, teacher action research has been advocated as an important professional development activity, which leads to sustainable teacher learning (Bransford, Brown, & Cocking, 2000; Elliott, 2001; Zeichner & Klehr, 1999). For example, there are many reports on the involvement of science teachers in action research projects (Bennett, 2002). Through explicit inquiry and critical reflection on their own teaching practice, action research provides opportunities for teachers to develop pedagogical content knowledge, to refine beliefs and activities around teaching and to gain confidence in promoting student learning (Lundeberg, Bergland, Klyczek, & Hoffman, 2003; Zeichner, 1997; Zeichner & Klehr, 1999). As discussed earlier, due to the limited training and the uniqueness of the field of computing, there is a great need for teachers to learn more about teaching computing.

Secondly, to address the issue of teacher isolation and the need of support from other teachers, DCCE borrows the idea of Disciplinary Commons (Fincher & Tenenberg, 2007; Tenenberg & Fincher, 2007). The Disciplinary Commons project emphasizes the sharing and documentation of knowledge about teaching and student learning using a course portfolio and the creation of a community of peer teachers who review each other's teaching through a series of monthly meetings. Through participation and reification within a community of practice (Wenger, 1998), the college faculty participants in the Disciplinary Commons projects found values of the project including offering opportunities to systematically reflect on teaching practice and learn skills that apply directly to their teaching practice (Tenenberg & Fincher, 2007). The Disciplinary Commons project offers a mode of "building a community of scholars who can engage with and support each others' practice" (Tenenberg & Fincher, 2007). In the first DCCE teacher cohort, we gathered introductory CS teachers from both HS and undergrad levels, who naturally shared common interest in the knowledge of and approaches to teaching introductory CS.

In addition to the common discipline the teachers are teaching, the DCCE program also provides venues to enhance communication among the different levels of teachers, which is similar to the idea of teachers' vertical teaming used in K-12 education (Kowal, 2002). Related work on vertical teaming shows that, in addition to enhancing communication on curriculum standards and how different teachers interpret and teach the standards at each grade level, the collaboration and networking in a vertical team provides a support system that reduces teachers' feelings of isolation and promotes greater enthusiasm for their teaching (Bertrand, Roberts, & Buchanan, 2006; Kowal, 2002). In the DCCE program, we attempt to offer cross-level communication opportunities to help teachers further their understanding of the computing field and computing education at different levels, and eventually gain insights on how to best prepare students and improve the transition of students from different levels.

Modes of Inquiry

Research in this project is informed by the methodological framework of design-based research (Barab & Squire, 2004; Brown, 1992). Through three iterations of design, implementation and evaluation of the DCCE program, we attempt to further understand computing teachers' professional development needs, and explore the ways that DCCE can offer support for computing teachers and the potential learning that teachers may gain through their participation in the DCCE program. In this paper, we report the results from the first year pilot program.

Data Sources

In the first DCCE teacher cohort, we invited 8 computing teachers: four HS teachers and four college faculty from different institutions in Georgia. Multiple data sources were used to evaluate the quality of the DCCE program and its impact on teachers' perception and practice.

First, we used meeting feedback forms at the end of each meeting to gather formative information as to what extent we achieved the meeting objectives. The external evaluator of this project gathered feedback after each meeting and then sent the reports back to the researcher team of this project before the next meeting. Thus, these data also served as feedback for planning the successive meetings.

Second, we also distributed a baseline survey related to teachers' perception of themselves as computing teachers and a post survey after the last meeting to assess to what extent the DCCE achieved some of the positive effects on teachers as a result of conducting action research, reported by other action research projects (Zeichner & Klehr, 1999). These surveys included a set of Likert scale questions and open-ended questions. In total, all eight participants completed the baseline survey, while seven (four HS teachers and three college faculty) of the eight participants completed the post survey.

Third, to track the longer-term impact of the DCCE project, we also conducted semi-structured interviews using the Success Case Method (Brinkerhoff, 2003). The purpose of these interviews is to directly respond to our main evaluation question: What changes are teachers making in their classrooms as a result of program participation?

The Success Case method is a qualitative interview and analysis method that learns the effect of training or other programs by interviewing those who do the best at implementing the desired changes and those who are implementing at a low level or not at all (Brinkerhoff, 2003). To determine the success and non-success cases, each participant in the first DCCE cohort was ranked on the following six constructs by the DCCE organizers (the researcher team):

1. The level of support each teacher provided to other participants.
2. The level of support each teacher sought from other participants.
3. The level at which each teacher actively investigated student learning.
4. The level at which each teacher appeared to reflect on his/her practice.
5. The level at which each teacher discovered better forms of practice.
6. The level at which each teacher is likely to implement change in the classroom.

As a result, a success and non-success case was selected for both HS and post-secondary levels which results in four interview participants (as showed in Table 2). The external evaluator interviewed these four teachers the semester right after the DCCE cohort (Fall 2009) and a year after (Fall 2010) to follow up changes in their teaching practices. To protect the anonymity of each participant, we refer to all interviewees using feminine pronouns (her, she, etc.).

Table 2: Success and Non-Success Case Interview Participants

	Success Case	Non-Success Case
High School (HS)	Interviewee A	Interviewee B
Post-Secondary	Interviewee C	Interviewee D

Preliminary Findings

Overall Results

Using the multiple data resources, we are attempting to examine, to what extent and in what ways, the DCCE program has achieved its goals. Overall, the participants reported that they enjoyed and valued the first DCCE program. Firstly, the participants rated most of the meeting agendas at 3.5 or higher (from 1 to 4, e.g., 1 as *not* informative and 4 as informative), in terms of how informative, engaging and useful each agenda was. This result indicates that the participants were satisfied with the overall quality of the meetings. The participants also evaluated the degree to which they perceived the learning objectives defined for each meeting were met. As with the agenda items, we asked each participant to rate the degree to which the meeting addressed each learning objective on a semantic differential scale from 1 (Not at all) to 4 (To a great extent). Overall, the feedback was positive, with an overall average rating of 3.5 for all meetings.

Secondly, most of the participants reported that they benefited from the DCCE activities. Among the 7 responses of the 8 participants, 6 of them reported that through DCCE, they learned to better analyze their own teaching, felt less isolated and more supported and became informed of diverse resources and perspectives on teaching computing courses. In particular, comparing the pre- and post- surveys, the participants felt less isolated in their teaching after their participation in DCCE, with 7 of 8 participants feeling isolated before the DCCE and 2 of 7 feeling isolated after the DCCE. In addition, all of the seven participants reported that they knew where to find support about teaching computing courses after the DCCE.

The next section presents the results from the interviews, which indicates both cases of teachers who were able to made changes in their teaching practices driven by their experiences in the DCCE cohort and who were unable to identify or implement those changes. We also discuss another goal of the DCCE cohort: to what extent the teachers built connections with other participants through the DCCE cohort.

Changes in Teaching Practices

Desires to Change for Improving Teaching

Through the interviews, the participants reported changes that they were planning to implement in their classrooms, inspired by their participation in the DCCE cohort. As showed in Table 3, examples of changes include putting more emphasis on code comprehension, implementing daily quizzes to diagnosis student learning, and working on improving student motivation. Overall, both teachers of success case identified specific plans to change, inspired by their experience in the DCCE cohort. However, the non-success case teachers' plans were vaguer and did not identify clear or measurable goals for the year. For example, the non-

success case HS teacher reported she would like to work on improving student motivation. She explicitly expressed the importance of student motivation and discussed a series of approaches to teaching computer science that had failed to motivate students. However, she did not offer specific ideas that she was planning to implement in her classroom.

Table 3. Intended Pedagogical Changes by Participants

Interviewee A (HS, Success Case)	1. Model problem-solving process including making programming mistakes 2. Implement code comprehension activities 3. Use daily quizzes for routine feedback
Interviewee B (HS, Non-Success Case)	1. Work on student motivation
Interviewee C (Post-Secondary, Success Case)	1. Implement code comprehension activities 2. Incorporate pair programming into lab sessions
Interviewee D (Post-Secondary, Non-Success Case)	1. Try to make programming more interesting (improve student retention)

Pedagogical Change Driven by Action Research Experience

Through conducting the action research projects, the participants were able to question and reflect on their own teaching. They were able to better understand how their teaching worked or did not work for their students, and then identify needs of change in their teaching. For example, the success case HS teacher reported a specific pedagogical change (modeling programming mistakes for her students) she made as a result of her action research experience.

In one action research project, the participants delivered a survey to understand their students' attitudes toward programming. Through this study, the success case HS teacher learned that her female students felt a sense of failure every time they found a compiler error or had to change part of their program, but the male students did not report the same level of failure. This teacher learned that she needed to help her students, especially the females, understand that programmers change their designs and that this is not a sign of failure but rather a natural part of programming. As a result of conducting this study, she identified a specific pedagogical change and implemented it in her classroom: In her class, she intentionally demonstrated her thought process while writing code and actively changing the design of her code.

> *"What I took out of that[project] was I am going to model mistakes on the board or on the overhead projector more often and not just making a typo, but maybe attacking a problem in a different way, and then saying, 'You know what? On second thought, I don't think this was the right approach. Let me erase this and let me start over' and not show that it's a mistake. Show that it's just part of the design process that you're always going to constantly redesign and that's not failure."*

Moreover, this teacher also learned and identified another change needed in her teaching through conducting another action research project about code comprehension. Code comprehension is one of the important learning goals of programming courses. Students are expected to be able to read a piece of code and then tell at a high level what the code is doing (e.g., sorting). Through this project, she found that most of her students did not do well in code comprehension. Thus, she identified the need for her to implement more code comprehension activities as a result of the DCCE program.

Similarly to the HS teacher, the university faculty (success case) also reported her plans to use code comprehension in her assessment, inspired by her experience in the code comprehension project.

Changes Made over a Year after the DCCE Cohort

Success Case

As presented above, the participants (both success and non-success cases) mentioned right after the DCCE cohort that they intended to make some pedagogical changes for the upcoming school year. The success case teachers were able to implement the intended changes and saw immediate results with their students. For instance, the HS teacher (interviewee A) spoke about modeling programming mistakes for her students in her original interview in 2009. The follow-up interview with her in 2010 revealed that she had indeed implemented this change and was noticing improvements in student attitude as a result of this change.

> *"So, I try to model mistakes so that when they make mistakes, they understand that it's just a mistake that happened and it's not a failure…So, modeling their mistakes and creating an*

environment where they understand that mistakes are part of life, and they just have to be fixed is something I work very, very hard at. And the transition is so obvious in my classroom. Because the first week of school, the students, they'll beat themselves up…Then two months later, they'll say, 'Oh, yeah. I'm behind you, but that's just because I'm slow. I'll get there eventually.' That feeling of, you know, 'Maybe I'm behind, but that's okay,' is huge to me. I think it's helped my students understand that in Computer Science."

She also implemented daily quizzes that she had described the previous year. Having her students take a very short quiz each day did cause changes in student code writing capabilities, as well as studying behavior.

"Then all of a sudden, when the students started coming in the classroom, they started looking at their notes before the daily quiz. I thought, 'Wow! Those kids are reading their notes? This is like the greatest invention ever!' I got it so that the quizzes were very easy to grade…I really noticed improvement. Now, not my overall student scores…But just on a simple level, they weren't writing garbage ever…I saw it improved my students' confidence and their level of writing code."

Finally, the success case HS teacher already intuitively asked her students to do code comprehension exercises, even before her participation in DCCE. The action research project on code comprehension revealed the importance of code comprehension exercises. Therefore, she focused on it more heavily in the following year.

Overall, the success case HS teacher set clear goals for the year based on her experience in the DCCE cohort, and was able to achieve those goals. Furthermore, she noticed positive results once the changes were implemented, and continued them in her daily teaching practice.

As to the success case university faculty (interviewee C), while she did not teach the relevant class and was unable to implement the use of code comprehension activities, she did indeed pursue the pair programming idea over the past year. She introduced her ideas of pair programming in the DCCE meetings and received positive feedback from other participants. She then planned to incorporate pair programming into her lab course and did implement in her school over the past year.

"Well, one idea that I had, was using pair programming in the CS1 class. So, I did it on my own, and I presented my findings to the [DCCE] group. I got some positive feedback. I'm actually using it again this semester. I'm actually involving another colleague. So, there will be two of us now trying the same to get some more results from that."

[One year later]:

"That's something that I have been trying for a number of semesters, that in fact last semester/this semester I taught a couple of colleagues to try it in their classes. We made some observations and tracked these through papers and then brought an exemplary contrast as well. So, we're very much into pair programming in our school."

In particular, she also made changes to the way she assessed students as a result of using pair programming. Her implementation of pair programming allowed her to develop grading strategies to address fairness in assessment during the past year. While she admitted that there was room for improvement in the details of implementation, she stated with confidence that "collaborative effort improved the performance of the students."

Non-Success Case

In contrast, the non-success case teachers revealed that they made no additional changes to their teaching since the initial interview. Both of them had originally described some ideas of motivating students or making programming more interesting they learned during their participation in DCCE; however, during the past school year, they did not make any other changes.

Peer Support Formed through the DCCE Cohort

One goal of the DCCE program is to offer a local community for the teachers to make connections and support each other. Both success and non-success cases reported that the participants in the DCCE cohort were all collaborative during the monthly meetings and supported one another at those times. However, such collaborative connection did not sustain for all of them after the DCCE cohort.

On one hand, the success case HS teacher continued to participate in the DCCE program, and also continued contact with members of the original DCCE group. She explained that she intended to continue collaborating with her peers, as she valued this interaction and opportunity to learn new strategies.

"I'm almost 100% sure I've heard from everyone at least once, but not in a regular like partnership or a collaborator…I don't know if teachers in general are very much true to their classroom and don't want to collaborate because they think they can nurture themselves. But I worship collaboration. I love to work with others. I love to share my wealth of knowledge, and I love to collect other people's knowledge."

To extend the connection opportunities, she also volunteered to serve as a teacher leader for the second DCCE teacher cohort.

On the other hand, the non-success case HS participant discussed limited support both sought and received after the DCCE. She cited lack of time as the reason for no longer participating and not interacting with former participants. Unfortunately, neither of the two faculty members (both the success and non-success cases) continued interacting with other DCCE members in the past year after their initial participation in the program. They described not participating in the current DCCE cohort as the reason for no longer interacting with other members.

"But I'm a bit out of contact with the group now. I mean, if anyone contacts me, I'll be very happy to communicate. Just not being there and not being actively involved, you know, that just doesn't occur to me."

Conclusion and Discussion

Our preliminary results from the DCCE project evaluation indicate that the first DCCE teacher cohort was able to achieve some of its goals in supporting teacher learning and promoting change. Through meeting with other CS teachers and collaboratively conducting action research, these teachers were able to actively share and investigate their own teaching practices, get exposed to better forms of practice, as well as question and reflect on their own teaching. They were thereby able to better understand their own teaching and identify needs of change for improving their teaching. Meanwhile, we also found that although the participants felt their experience in the DCCE cohort as beneficial, not all of them were able to continue their connections with other participants after their initial participation in the DCCE program.

Our findings from the interviews with the success case and non-success case teachers also indicate that teachers who more *successfully* participated in the DCCE activities were better able to identify specific change plans and implement those changes in their classrooms afterwards. Therefore, as the program organizers, we need to ensure that our facilitation efforts help participants engage in those communication and reflection activities. One lesson we learned through this pilot program is that teachers are not necessarily familiar with action research and therefore need scaffolding. In the first year DCCE cohort, the participants experienced challenges during their participation in action research projects. Meaningful dialogues did not naturally occur in the first few meetings among the participants. The teachers were unable to come up with common questions/issues to investigate from their own teaching. They also struggled with the techniques and research process as other action research projects have reported (Zeichner & Klehr, 1999). To address this issue, we adjusted the project pace and offered more scaffolding such as introducing research methodology, providing examples of projects, and offering a reflection worksheet to guide teachers' consideration of the implications of the project findings for their own teaching.

While we still believe that the action research model might result in significant improvement of computing education practice, we believe that there are challenges in getting CS teachers to develop a research perspective on their own classrooms within the context of DCCE. Therefore, in the second DCCE teacher cohort, we adopted the course portfolio model, which has been successfully implemented in the Disciplinary Commons project (Tenenberg & Fincher, 2007). Participants in the second DCCE cohort engaged in collaborative course portfolio production. Additionally, each teacher also visited another teacher for peer-observation and feedback. Our evaluation results indicate that this alternative model was more successful in getting teachers talking about their practice, identifying ways of improve and generating a sense of community among teachers (Ni, Guzdial, Tew, Morrison, & Galanos, 2011).

Contributions

Due to the changing nature of the computing field and the relative newness of computing education research, we know little about those fundamental agendas necessary for computing teacher education. For example, what do computing teachers need to know for effective teaching? What have teachers already gained about those bodies of knowledge from teacher preparation programs? What are the most critical supports computing teachers need? This project is by no means able to answer all of the above questions. However, this first attempt allows us to see the need and potential merits of building a community with a focus on reflection for computing teachers. This is also an attempt to explore how related teacher education research outside of computing might help us address the challenges for supporting computing teachers.

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