Adapting the Disciplinary Commons Model for High School Teachers: Improving Recruitment, Creating Community

Briana Morrison, Lijun Ni, Mark Guzdial
School of Interactive Computing
Georgia Institute of Technology
85 5th Street NW
Atlanta, GA, 30332-0760
bmorrison@gatech.edu, {lijun, guzdial} @cc.gatech.edu

ABSTRACT
The Disciplinary Commons (DC) is a model of teacher professional development that encourages members of the group to reflect upon their teaching practices, develop a community, and, more broadly, to become more scholarly about their teaching. The DC involves a series of monthly meetings where university faculty members examine their course in detail while producing a course portfolio. Evaluation of the early DC's suggests that they successfully created a sense of community and sharing among the participants. We have adapted the original model to a new audience, high school computing teachers. The adapted model maintains the key aspects of the original model while adding two new, important goals for this new audience: improving recruitment and creating community. The high school teacher audience particularly needed strategies for recruiting students and was in greater need of community. We present evaluation evidence suggesting that we achieved the design goals in a replicable model, including a substantial increase (over 300%) in recruiting students.

Categories and Subject Descriptors
K.3.2 [**Computers and Education**]: Computer and Information Science Education: computer science education, information systems education

General Terms
Measurement, Documentation, Design.

Keywords
Disciplinary Commons, K-12 computing teachers, community.

1. INTRODUCTION
A *Disciplinary Commons* (DC), developed by Tenenberg and Fincher ([1, 2]) involves a group of educators from diverse institutions who teach within the same subject area meeting monthly over an academic year. In monthly increments, the participants prepare a *course portfolio.* Unlike a *teaching portfolio* ([3, 4]), which provides a perspective on a teacher over time across a range of courses, the *course portfolio* [5] describes the teaching of a single course during an academic term. At each meeting, participants focus on a separate aspect of teaching and learning, for example: situating the subject taught within an institutional and departmental context; examining the course content (via syllabus documents, or comparing textbooks chosen); considering the instructional design adopted and how it is appropriate for the content; sharing how material is assessed and how learning is evaluated. Artifacts that participants bring in from their own classrooms (for example, lesson plans, syllabi, assessments, examples of student work) anchor each of these discussions.

We called the Georgia version the *Disciplinary Commons for Computing Educators* (DCCE) which was funded through an NSF Grant. Our aim was to involve both college and high school educators, because we realized that there was interest in bridging the secondary/post-secondary school divide [6].

The high school teachers had a different set of needs than the higher education faculty. High school teachers have an increased need for community. They normally teach in isolation as the only computing teacher at their school [7]. In Georgia, as in most US states, high school computing teachers are placed in the business department [8]. This means that even when they attend department meetings they are grouped with business class educators (e.g., accounting and keyboarding). The lack of a community can reduce teacher confidence and performance.

High school teachers also have a greater need to recruit students for their computing classes. CS classes are electives for US high school students. There are no CS majors in high school. If enough students aren't recruited for the classes, the classes aren't scheduled and the teachers are then required to teach other, non-computing classes.

Because of the different needs of high school teachers, we adapted the original DC model. Our iterative approach and evaluation addressed the following research questions: Can the DC model be adapted to support high school CS teachers and still be successful? What components should be modified and what content should be added? Are the benefits to high school CS teachers the same as for college faculty?

The DCCE ran for three academic years with three separate cohorts. The first year took a different approach from the original DC as it used an action-research model, but we found that the model didn't work as well as we'd hoped. In the second year we implemented the traditional portfolio model. In the third year we again used the portfolio model, but in that year, the

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.
ICER'12, September 9–11, 2012, Auckland, New Zealand.
Copyright 2012 ACM 978-1-4503-1604-0/12/09...$15.00.

group of participants involved only high school educators, which allowed for greater adaptation.

The next section discusses the background of the DC including previous instantiations and findings. We present the implementation of the DCCE model in detail for years two and three and the corresponding evaluation results. We end with a discussion of the implications of our findings.

2. BACKGROUND

2.1 Defining a Disciplinary Commons

The Disciplinary Commons was created in 2005 by Fincher and Tenenberg [1, 2] who ran the first two instantiations in the UK and Washington, USA, respectively. The initial cohorts all involved members in higher education. The original goals of the DC were twofold:

1. To *document* and *share* knowledge about student learning in Computer Science classrooms.
2. To establish practices for the scholarship of teaching by making it *public*, *peer-reviewed*, and amenable for *future use and development* by other educators. [2]

The objectives were accomplished through the production of course portfolios by the participants. In the traditional DC model, participants meet once a month during the academic year to discuss teaching and assessment within their discipline, while participants construct a teaching portfolio. Each meeting is targeted on a specific piece of the course portfolio, as seen in Table 1 [2].

Table 1. Monthly Meeting Topics

Meeting	Month	Portfolio Section
1	September	Institutional Context & personal trajectory into teaching
2	October	Curricular Context
3	November	Course Content
4	January	Instructional Design
5	February	Student Assessment
6	March	Evaluation
7	April	Delivery (including debrief of peer observation)
8	May	Complete "first draft" overview
9	June	Portfolio Presentations

2.2 Evaluation Results

External evaluation of both of the original DC's used surveys and semi-structured interviews. In examining the evaluation results of the original DC goals, the first goal was met, but not the second [9]. The participants were overwhelmingly positive about the experience, agreed that it was a good use of their time, and would recommend it to colleagues. However the participants reported that they would use their portfolio for their own purposes as opposed to public dissemination [9]. The participants did make use of each others' content, suggesting a willingness to share and reuse [1].

Two additional outcomes were discovered through the evaluations. The first was the development of a strong and vibrant *community*, not an explicit original goal of the DC. A second outcome discovered was the *change of practice* as a result of participation. While neither of these outcomes may have been unexpected, perhaps the strength and amount of change could not have been predicted.

Analysis of surveys from participants after the original DC offerings revealed that 100% of the participants indicated that they reflected on their own teaching at least several times each term. 58.9% indicated a change in their teaching practices at least once per term based on these reflections. The participants indicated that the most valuable part of the DC experience was the community, the opportunity to share ideas, learn from each other, and become more connected to like-minded colleagues [10].

Evaluations were also completed on the 2009-2010 replications of the DC held in Illinois (Software Engineering centered) and the UK (Database centered), led by different facilitators. These realizations were true to the original model with the only changes being the discipline and the facilitators / leaders. These replications had similar results to the original DC offerings in that the participants enjoyed their experience and felt their decision to participate was a good one. However, these replications were not as successful in meeting the original first goal of the DC (only 35.3% completed their portfolio and 41.1% indicated their portfolio needed revision) [11]. The participants expressed concerns about sharing their portfolios, although 76.5% indicated they may share their portfolio with instructors from their own departments. (Only 47.1% of the participants indicated adopting practices from other participants.) The participants reported that the peer review process was difficult because participants were not always able to keep up with the proposed review schedule [11].

3. OUR MOTIVATION

Our original motivation in creating the Georgia DCCE was to promote the communication and community between high school and college teachers around teaching of introductory programming. We hoped to see teachers (1) creating community as in the original DCs (e.g., as evidenced by promoting the opportunity for future collaborations), and (2) sharing resources and knowledge of how things are taught in other contexts (e.g., as evidenced by change of practice). Later, we added a goal (3) of supporting student recruitment within the high school environment. Goals 1 and 3 are unique to DCCE. Goal 2 was our restatement of the original DC goals, yet we wanted to make explicit the desire for capturing and sharing of resources to make the teaching knowledge public and available for use by others.

4. IMPLEMENTATION

The DCCE was run three times in Georgia with participants from both college and high schools (Table 2). We found in our initial discussions with potential participants that there was interest on both sides in understanding and influencing the other side of the secondary/post-secondary school gap. High school teachers wanted to understand the context to which they were sending their students. The undergraduate teachers wanted to understand and improve high school computer science courses.

Table 2. DCCE Participants By Year

Year	High School Teachers	College Faculty
2008-2009	**5**	**3**
2009-2010	**4**	**4**
2010-2011	**8**	**0**

4.1 Year 1

The first year implementation was based on an action-research model rather than production of course portfolios. Based on survey evaluations from this first year of the DCCE, the action-research plan was not achieving our goals. The participants did not engage with the formation of research questions—that wasn't an activity common for high school teachers. We didn't see signs that the participants were forming a community, and we saw no signs of change of practice. Since the action-research model did not help us achieve our goals, the Georgia implementation model changed for the second year.

4.2 Year 2

During the second instantiation of the DCCE, both high school teachers and college faculty were recruited. We followed the design of Fincher and Tenenberg around a portfolio construction model. Recruiting started in August and the leaders of the Commons were a college instructor (first author) and a high school teacher who were participants in the Year 1 DCCE. The leaders borrowed meeting agendas and information from the previous Disciplinary Commons instantiations and adapted them for their participants.

Important changes made to the original DC model for our Year 2 implementation involved adapting the schedule and content of meetings. We added minor topics to each meeting specific for our Georgia participants, such as an overview of the Georgia university computing curricula, competitions available for high school students, and field trip possibilities in Georgia, among others. These topics became part of the working lunch at each meeting and served to build community among the participants. The main topics for each monthly meeting for the Year 2 DCCE can be seen in Table 3.

Table 3. DCCE Year 2 Monthly Meeting Topics

Meeting	Month	Portfolio Section
1	October	Personal trajectory into teaching
2	November	Institutional Context, Recruiting
3	December	Curricular Context, Course Content
4	January	Instructional Design
5	February	Teaching Philosophy, Reflection Log
6	March	Student Assessment, Grading Rubrics
7	April	Peer Observation Debrief
8	May	Student Feedback
9	June	Portfolio Presentations

A major adaptation to the original DC model was to combine course context and course content, as they were similar for both sub-groups of participants. All of the high school teachers were teaching, or planned to teach, AP CS. For the AP CS course, the curriculum is defined by the College Board, so the course content is the same for all of those teachers. For the college faculty, the introductory programming class is an entry level class at all of the institutions, thus their curricular context was similar. So we combined course context and course content into a single meeting concentrating more on the context piece.

The second major adaptation to the original model was adding a student recruiting module in November. We added the focus on student recruiting to support activities coinciding with the first National CS Education Week (CSEdWeek), held the first week of December. Recruitment is a more salient issue for high school teachers than college faculty. High school teachers typically teach more than just computer science [12]. The high school teachers see their potential students in their other classes or in the hallway. If they are successful in building up their enrollment, they get the reward of teaching more computer science and not splitting their time between multiple subjects. We used CSEdWeek as a natural opportunity to discuss what kind of outreach and recruiting strategies we could use during that week to raise the visibility of computer science at each institution. We discussed best practices of recruiting for courses, both at the high school and college level. Participants discussed strategies that worked for them and the group brainstormed additional methods of recruitment.

For the February meeting we added a component on teaching philosophy to encourage participants to explicitly state their beliefs and attitudes of the classroom environment and what they wanted their students to know or achieve upon completion of the course. This accompanied a reflection log homework assignment that required participants to document and reflect on a single teaching unit: their goals, instructional design, delivery, assessment, and reflection upon the overall success and failure of the unit and the individual pieces. Up until February, participants were finding it difficult to see the whole picture of the portfolio, just as participants in the original Disciplinary Commons expressed [9]. Participants felt they were lacking the "big picture" and were not connecting the pieces of the portfolio to the overall reflection practice. By making the reflection explicit in both the teaching philosophy and the reflection log they began to understand the connections.

Another adaptation came in the March meeting with a unit on grading rubrics. This occurred because of a request from the high school teachers for more information on how the AP CS test is graded (the free response questions) and how to incorporate that style of grading practice into their classroom. As one of the regional leaders was also a reader (grader) for the AP CS exam, an example grading rubric for a test question was presented. Participants were then asked to devise a grading rubric for a test question (student assessment mechanism) they had brought with them to the meeting. Discussion on assessment mechanisms, fitness of test questions, and grading schemes resulted. Adding the discussion on grading rubrics enhanced both the community and teacher reflection, specifically on assessment.

This led to the final adaptation of the meeting schedule, the Student Feedback meeting. An entire meeting was used to discuss formative versus summative feedback, wording of student feedback, useful examples of feedback, and ways to simplify the feedback process. Participants specifically requested more information related to assessment and feedback as their reflections led to questions about feedback on assessments. Discussions during the year revealed that the participants had a wide range of feedback practices which the participants wanted to hear more about and see examples. This served as another mechanism to build community and enhance the documentation of their teaching practices.

4.3 Year 3

In the final year of DCCE, we accepted only high school teacher participants and expanded beyond the state of Georgia. Not enough college faculty were recruited to have a balance of high school and higher education faculty as was originally planned for Year 3. During the previous year we found the high school teachers benefitted from the community building aspect of the DC more than the college faculty. We know that high school teachers often don't succeed without a community [13]. Without a community to identify with, they are less committed to teaching computing. In Year 3, eight high school computing teachers were recruited. They taught two different classes—6 of them taught AP CS and 2 taught introductory programming (a pre-AP CS programming course). The leaders were the same from Year 2.

We kept the same discussion topics from Year 2 as well as the content adaptations. In Year 3 there were eight meetings (Table 4). We removed one meeting by combining the Institutional and Curricular Context topics. Most of the high school teachers had very similar curricular context. Feedback from the participants in Year 2 indicated they felt these two topics should have been combined. The recruiting module was kept in November, again to tie into the upcoming National CS Education Week. Student Feedback and Peer Observation were switched only because of the timing of spring break so as to allow the participants ample time to schedule and complete their peer observation.

Table 4. DCCE Year 3 Monthly Meeting Topics

Meeting	Month	Portfolio Section
1	September	Personal trajectory into teaching, *Selection Structures*
2	October	Institutional & Curricular Context, *Repetition Structures*
3	November	Instructional Design, Recruiting, *Teaching Classes*
4	January	Teaching Philosophy, Reflection Log, *Arrays and Sorting*
5	February	Student Assessment, Grading Rubrics, *Recursion*
6	March	Student Feedback, *Inheritance / Polymorphism*
7	April	Peer Observation Debrief
8	May	Portfolio Presentations

There were three significant adaptations to the DC model added in Year 3. The first was an addition of a discipline specific content topic. In each month, a discipline specific content area was discussed (italicized in Table 4). For example, in November we discussed how each participant taught "objects" and "classes" to their students. The first topic area was picked by the leaders, but the remaining topics were nominated and selected by a vote of the participants. Each month the participants were asked to bring in an artifact or example of one piece of instruction for each content topic. Examples ranged from practice worksheets, test questions, and project assignments. These resources were all posted to the website to allow sharing among the participants. The purpose of this adaptation was twofold: 1) to increase the amount of resource sharing between participants and 2) to promote change of practice among the participants by providing them with easily adaptable, peer-reviewed resources.

The second adaptation in Year 3 was to the review process. Instead of asking participants to write one section of the portfolio and review two other participants' contributions, they were only asked to write (with an occasional outside reading) between meetings. The rest of the review was made part of the meetings. The first agenda item for each meeting was to review and discuss another's portfolio piece.

Reserving meeting time for the peer review of portfolio pieces yielded two benefits. First, it encouraged completion of the writing assignment by the participants. With less outside time required the assignments became more manageable. Also, to prevent embarrassment and appearing as a "slacker," participants were more likely to have completed their writing knowing that the first topic of the day was peer review. The second benefit of scheduling the peer review sessions during the meeting is that more in depth review and discussion occurred in the face-to-face reviews than occurred during the previous electronic based reviews. This improved the content of the portfolios and strengthened the sense of community as more participants had more in depth personal conversations with the other participants.

The final adaptation to the model in Year 3 was in holding two "mini-conferences" for the high school teacher participants combined with college faculty. College faculty are motivated by the presentation of scholarly work as this counts for yearly evaluation, promotion, and tenure. High school teachers want to attend conferences where scholarly work related to introductory computing classes is presented, but are often limited due to financial constraints. In order to encourage the cross-community building between college and high school teachers, we organized and held two mini-conferences, held in the afternoon of two regularly scheduled DCCE meetings to minimize travel for the high school teachers. College faculty and high school teachers were invited to submit proposals on topics that would be of interest to both subgroups of attendees. Presenters were both selected and recruited based on input from Year 2 and Year 3 participants. Invitations were issued to all Georgia college institutions and to high school computing teachers in the state.

5. METHOD

Year 2 and Year 3 of the DCCE collected similar data. Participants completed surveys before the first meeting and at the conclusion of the last meeting. These pre/post surveys were based on the original DC evaluation surveys.[1] We added questions to the surveys to allow us to derive a social network analysis. In addition, a feedback form was completed for each meeting discussing whether the goals for the meeting were met and eliciting suggestions for improvements in future meetings. All data was recorded and analyzed by an external evaluator, The Findings Group, who produced reports. The external evaluator also conducted phone interviews with participants from Year 2 and Year 3 for qualitative results. The Year 2 participants were invited back for a reunion meeting six months after the conclusion of their DCCE. Survey data on this meeting was collected also.

[1] Original DC pre and post surveys can be found at http://depts.washington.edu/comgrnd/leaders/DisciplinaryCommons_PrePostSurveys_R5.docx

The purpose of the survey questions was to determine if the goals for specific meetings were being met and if the adaptations made to the original DC model were effective. Survey results for the meetings and the overall effectiveness of the DCCE have been reported previously [6, 12, 13]. This paper reports on the results from Year 3 and the social network analysis of Year 2 and Year 3.

6. RESULTS

Overall approval of the DCCE experience was similar to the original DC's. On a 5 point Likert scale where 1 signifies "strongly disagree" and 5 signifies "strongly agree", Year 3 participants rated their overall DCCE experience a 4.75, while Year 2 participants rated their experience a 4.86. All participants indicated that they would recommend the DCCE to a colleague by responding either "definitely" (majority), "very probably" or "probably" (average of 5.25 on 6-point Likert scale where 1 signifies "Very probably not" and 6 signifies "definitely"). They also indicated that the DCCE was a good use of their time (88% agreed or strongly agreed with this statement).

In evaluating the goals for the DCCE, we examine our results based on the original goals defined for the DCCE.

6.1 Building Community (DCCE Goal 1)

The DCCE had two additional goals beyond those of the original DC: building community and encouraging student recruitment. While the original DC noted that the participants created and felt part of a community, it was not explicitly measured. For the DCCE, a social network analysis was completed for each cohort. Social Network Analysis (SNA) is a method for studying social relations among a set of participants. SNA is the mapping and measuring of these relationships among individuals. Measurements include the **density** (a number between 0 and 1 indicating how inter-connected the nodes are in the network), **degree** (count of the number of edges or paths that are connected to a node), and **betweeness centrality** (quantitative value that identifies individuals who act as a bridge to the rest of the group) [14].

For Year 2 of the DCCE, the average participant did not know 95% of their DCCE peers prior to their participation in the program. By the conclusion of the DCCE, the average participant knew and had collaborated with 88% of their DCCE colleagues. Participants reported that they shared materials and ideas with 32% of their DCCE peers and formally worked on a at least one project with 34% of their DCCE peers.

Due to space limitations, only the sociogram from Year 3 is shown (Figure 1). The sociogram for Year 2 is similar. For Year 2, the sociogram representing the relationships prior to DCCE suggests a disconnected and clustered social network whereby high schools and college/universities were disconnected and isolated from one another. Also, the social network within the high school teachers has a hierarchical structure such that one or two individuals served as the primary communication hub.

After DCCE, the network of participants expanded and became more integrated; high schools and college/universities were more interconnected. The density of the network for Year 2 likewise grew by 100% (Before= 0.29, After=0.58; Scale= 0, low density to 1, high density) indicating a moderately interconnected community of computer science instructors.

It is important to note that despite the increase in density from pre to post, the social network structure upon completion of the DCCE program (post) for Year 2 revealed that one participant played an important role in bridging the group together. One

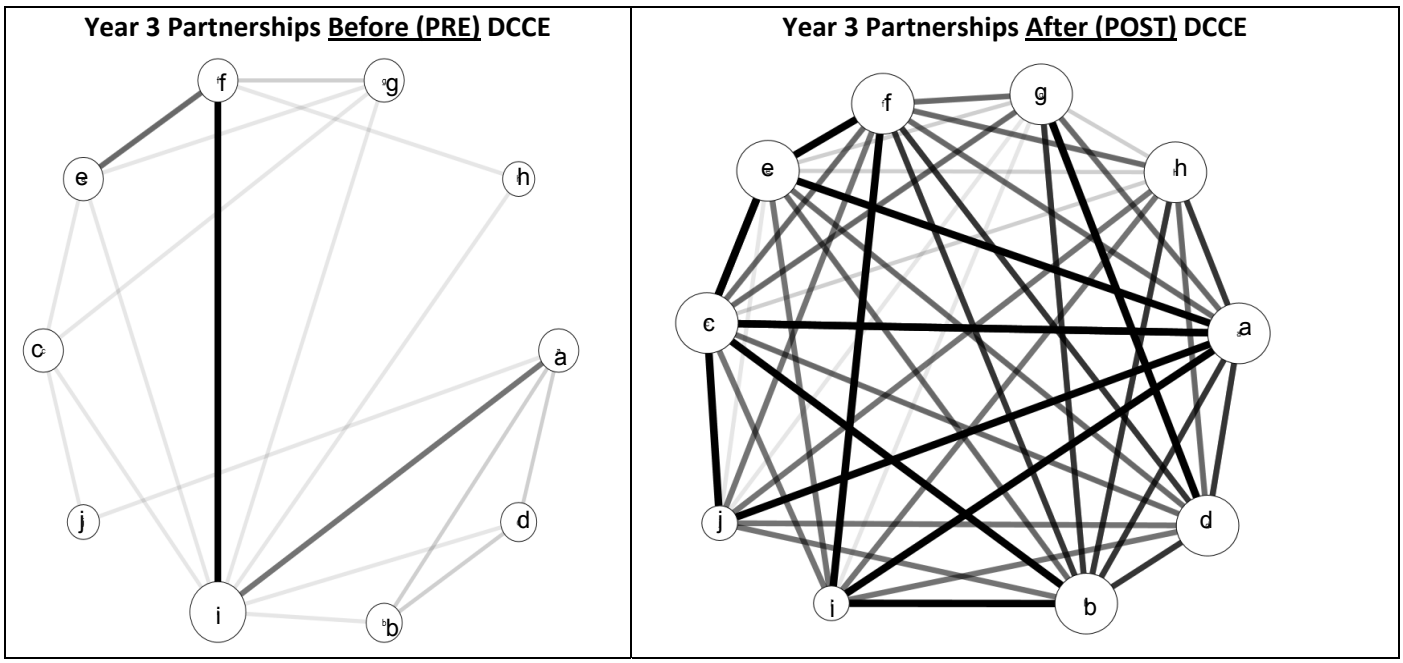

Figure 1. SNA Analysis For Year 3

Note. Omitted edges (paths) signify no interaction between participants ("*I did not know this person at all*.")

Key: Density and Opacity of edges (paths) signify type and/or quality of interaction between participants: **thin line/most transparent**= "*I knew this person but we have never collaborated*" **medium line/moderately opaque**="*We shared materials and ideas, but never formally worked on a project together*" **thick line/most opaque**= "*We formally worked together on at least one project*." Size of node (participant) signifies degree of popularity (i.e. large circles= popular participants)

participant had a betweeness centrality score of 14.867, suggesting that she was vital for assuring that information was communicated across the network. The other participants for Year 2 had betweeness centrality scores ranging from 0 to 8.367. Reducing the number of participants who serve as "bridges" or "connectors" will increase the density of the network and ensure that such individuals do not create a bottleneck effect in which the performance or capacity of an entire network is limited by these few individuals. This was accomplished in Year 3.

In Year 3 of DCCE the average participant did not know 67% of their DCCE peers prior to their participation in the program. As a result of their participation, the average participant reported that they had interacted with 100% of their DCCE peers. They had shared materials and ideas with 53% of their DCCE peers and formally worked on at least one project with 18% of their peers. The amount of collaboration increased as well. Participants reported that they collaborated with less than 3% of the organizations represented by their DCCE peers before their participation in the program. After DCCE, the average participant reported that they had received advice, materials, or other help from faculty at 50% of the organizations and worked on at least one project with 21% of the organizations represented.

The SNA for Year 3 is shown in Figure 1. The left side of Figure 1 suggests a hierarchical network structure whereby one individual served as the primary communication hub. Prior to DCCE, one participant ("i") played a critical role in bridging groups together; she served as the informal linkage between groups.

Figure 1 on the right illustrates a non-hierarchical network structure whereby all individuals play an equal role in transferring communication and materials across the network. A nonhierarchical network structure indicates 1) low key leadership - decision making is shared among cohort members, 2) community action among members - activities are orchestrated as a group, and 3) little conflict and informal communication – in general there is little conflict among the members of the network and most communication between members is informal in nature. According to previous research, this network structure is best for facilitating 1) common understanding, 2) a clearinghouse for information, and 3) a base of support [14].

After DCCE, the network of participants expanded and became more integrated. The number of connections in the network expanded 132% from before the DCCE to after the DCCE. This difference in the number of partnerships established before DCCE and after DCCE is statistically significant ($p<.05$ using a paired samples t-test), as measured through the SNA. The structure of the network also changed: All participants have merged into a single large community and a more tightly clustered community. The density of the network likewise grew by 265% (Before= .267, After=.977; Scale= 0, low density to 1, high density) indicating a highly interconnected community of computer science instructors.

6.1.1 Overcoming Isolation

Part of building community is to allow the high school teachers to reduce their feeling of isolation. The DCCE was especially effective at reducing their perception of isolation in their teaching. A Year 2 high school teacher commented:

> *I felt like I didn't belong to a community at all of CS teachers until DCCE. But now I have a lot of teachers that I would feel fine about either calling up or emailing. That did not exist before. That's one reason I think it's so important that we have things like DCCE, because CS teachers are usually pretty isolated in high schools. That has now been changed because now I know a lot of people that do what I do.*

Another commented:

> *The [DCCE] group, for me, was so helpful in solidifying or making me want to continue to teach in Computer Science, because it was a group where I could share a Computer Science question, an issue and how did you deal with this. We're on islands.*

A Year 3 participant commented:

> *Computer Science teachers don't have this opportunity to get together with other Computer Science teachers because we're the only one. I'm the only one in the county.*

Another commented:

> *It's basically a way to create community, especially because most of us, I think pretty much all of us teach in a school where we are the only Computer Science teacher.*

The key to this is that the participants report that the DCCE allowed them to obtain feedback in a safe, comfortable, and reassuring environment. They felt this support made them more accountable and motivated to be good teachers. The DCCE also allowed them to develop an awareness and appreciation for the diversity in their teaching environments. The awareness and appreciation of the diversity in teaching environments facilitated teachers' realization that the pedagogical practices that worked for one teacher within their own teaching context may not work for another teacher. This in turn, prompted teachers to reflect on their own teaching context and to objectively assess and select what worked for them the best.

6.2 Sharing Resources (DCCE Goal 2)

The original DC goals were to (1) document and share knowledge about student learning in CS classrooms and to (2) establish practices for the scholarship of teaching by making it public, peer-reviewed, and amenable for future use and development by other educators [2]. These were restated as goal 2 for the DCCE: sharing resources and knowledge of how things are taught in other contexts (e.g., as evidenced by change of practice)

6.2.1 Meeting Original DC Goals

Our adapted versions of the DC met both of the original DC goals. Through completion of their portfolios the participants documented what was occurring in their CS classrooms. All participants in both Year 2 and Year 3 completed their portfolios. In Year 3, less than half of the participants had completed a course portfolio prior to DCCE. After completing DCCE and their portfolio, most participants reported that they planned on reviewing and revising their portfolios in the future and using their portfolios to reflect and refine their teaching philosophies. By having their portfolios peer-reviewed during the DCCE and then published on the websites, we met the second original goal of the DC. In addition, of the Year 3

participants, 62.5% intended to share their course portfolios with instructors in their own or in other institutions.

The original DC measured success by improving the quality of teaching in Computer Science (CS). This is accomplished through a change in practice of the participants, both through self-reflection and transfer [1]. The DCCE was a success based on these measurements. We increased participant self-reflection and measured a change in practice. 63% of the Year 3 DCCE participants reported that they reflected on their teaching at least once a week after completing the experience. An additional 25% indicate they reflect at least once per term. 88% indicated that they document their reflections on their teaching at least once a term (only 51% reported documenting their teaching reflections prior to DCCE). Transfer is discussed under change of practice below.

6.2.2 More Reusable Resources

Specifically the addition of adding discipline specific content topics increased the number of shareable and reusable resources available from the DCCE. By providing an online repository for participants to upload their resources allowed access beyond the duration of the DCCE. This adaptation was also seen as beneficial by the participants:

> *I felt like this [discipline specific content discussions] was probably one of the most helpful parts for me. It was basically because I got to see what other teachers were using in the classroom and what was successful for them. I think this is valuable for any teacher with anything that you're teaching. ... So, the DCCE allowed me the opportunity to meet with other teachers and go over things that worked out and things that didn't.*

Another teacher commented:

> *It was very helpful. That was the most helpful part. To me, that's what I went to immediately. You know, I talked earlier about getting tools to use in the classroom. That's where I got my tools was from the best practices. And I felt like if I could contribute a few decent things to that, I felt like I was making a contribution. But the more experienced teachers were the ones who really contributed to that, and I think the less experienced really drew upon that.*

6.2.3 Change of Practice (DCCE Goal 2)

100% of Year 3 participants reported that they gained new ideas for teaching practices from the DCCE. 88% indicated they would definitely adopt a practice from the DCCE and 63% indicated they would make changes to other CS courses based on their DCCE experience.

A Year 2 participant commented:

> *After seeing [another teacher] teach, I realized that there were definitely a lot of things I could do in my own teaching to improve. It really inspired me a lot and made me realize I've got a lot of room for improvement… I definitely have a lot of plans of how I will do things differently.*

The most common change of practice that the teachers made in their class was in the area of assessment. One Year 3 teacher commented:

> *Some of the things that I did, for example, were different ways of questioning. There was at least one month where we focused on how we ask questions and the types of questions. So, I really started to pay more attention to when I give assessments or testing quizzes, and making sure the questions are asking what I want them to ask, and that they're also modeling after the AP exams, since that is the test that the kids have to take at the end.*

6.3 Improving Recruitment: Increasing the Number of Students (DCCE Goal 3)

One explicit adaptation of the DCCE from the original DC model was the inclusion of content related to student recruiting. This was measured by asking the high school teachers their current class numbers and the expected number of students for the following academic year. Because high school students register for next year's classes before the end of the current school year, the teachers had an initial idea of their class sizes before the conclusion of the DCCE. According these self reported numbers, the high school teacher participants increased the number of AP CS students in the year following their participation in the DCCE by 302%. During their year of participation in the DCCE the participants had a total of 122 students enrolled in their CS class. These same teachers had 491 students pre-registered for their CS classes for the year following their participation in DCCE. One teacher in Year 3 had a 700% increase in students in her AP CS class and attributed it to the recruiting help received from the DCCE, going from 3 students to 24.

Teachers felt that the DCCE had helped them with recruiting in two ways: 1) it provided them a platform to share their own recruitment ideas and also to obtain ideas from experts, and 2) it provided them with a sense of community where they were able to keep up each others' morale during their recruitment efforts. These were a result of the adaptations made in the DCCE of introducing a recruiting module and explicitly building community.

7. DISCUSSION

There were two additional goals measured for the DCCE beyond the original DC, that of building community and improving student recruitment. Community was built during the DCCE through a combination of the adaptations made. The quality of the partnerships also increased. Participants also reported a significant increase in the number of students registered for their classes the following year, in large part due to the recruiting module added. The addition of discussing rubrics and feedback to students resulted in the largest change of practice, as assessment was the most common area reported as changed by the participants. Additionally, the assessment and rubrics meeting was the highest ranked meeting among Year 3 participants.

One improvement to the original DC model was to alter the manner in which the peer reviews of the course portfolios are conducted. The original DC model involved a double review of each portfolio piece to be conducted before each meeting. In the original DC model and its replications, a common complaint among the participants was the amount of time involved in being a participant [10, 11]. By moving the peer reviews from before to during the meetings, we reduced the amount of time participants needed to dedicate to the DCCE. As a result, 75% of the Year 3 DCCE participants reported never missing a single homework assignment and the other 25% missed only one. The change to the peer review process had the additional benefit of improving the community aspect as the participants had the opportunity to have more in depth conversations for all participants throughout the experience.

An unexpected benefit of DCCE was an improvement of teacher confidence. A Year 2 teacher stated:

> *I think DCCE definitely did help [me feel more confident]. I think it was just being a part of a community of teachers that you can actually talk with about teaching. That gives you confidence when you don't teach it in a vacuum.*

They also felt that the tasks of reading articles on pedagogy and writing their own teaching portfolios had introduced them to good pedagogical standards and to the value of following those standards in their classrooms. For instance, one teacher commented:

> *I was surprised, but I really enjoyed writing the course portfolio. I'm not a writer. I don't particularly like writing things. But writing the course portfolio, reading the pedagogy sort of assignments before we wrote the portfolio was really helpful and really made me feel more comfortable in the education environment I was before.*

This increase in perception of their ability to teach may be evidenced in the participants' willingness to share their completed portfolios with others. This may illustrate confidence in their portfolio and its contents. A side effect of increased confidence may lead to solidification or a change in teacher identity [13]. This is especially important for high school teachers whose identity may be due to things outside of their control (e.g., area of certification, department, etc.).

8. CONCLUSION

The Disciplinary Commons for Computing Educators (DCCE) is an adaptation of the Disciplinary Commons. It achieved the original goals of the Commons and the additional goals of creating a statewide community of computing educators and increasing the number of students who enroll in computer science courses. It's important to note that Year 2's adaptations achieved our additional goals for the high school teachers, and Year 3 increased those outcomes. Thus, we see Year 3 as a positive refinement of Year 2's model. We are currently planning additional work with new high school disciplinary commons groups to demonstrate that our model is replicable.

9. ACKNOWLEDGMENTS

We would like to thank our co-leader, Ria Galanos, whose help and support were instrumental in making the DCCE a success. The Findings Group was the external evaluator for the DCCE and produced all the evaluation reports. Finally, we thank Josh Tenenberg and Sally Fincher for their continuing support in our adaptation of their work. This work is supported by the National Science Foundation CPATH program under Grant No. 0829601. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

10. REFERENCES

[1] Fincher, S. and Tenenberg, J. Warren's question. In *Proceedings of the third international workshop on Computing education research* (Atlanta, Georgia, USA, 2007). ACM, New York.

[2] Tenenberg, J. and Fincher, S. Opening the door of the computer science classroom: the *Disciplinary Commons*. *SIGCSE Bull*., 39, 1 2007, 514-518.

[3] Seldin, P., Miller, J. E., Seldin, C. A. and McKeachie, W. *The teaching portfolio: A practical guide to improved performance and promotion/tenure decisions.* Jossey-Bass, 2010.

[4] Yellin, J. M., Huang, Y., Turns, J., & Tsuruda, C. *Teaching portfolios in academia: How are they used?*. Chicago, IL 2006.

[5] Hutchings, P. *The Course Portfolio: How Faculty Can Examine Their Teaching To Advance Practice and Improve Student Learning*. American Association for Higher Education, 1998.

[6] Ni, L., Guzdial, M., Tew, A. E., Morrison, B. and Galanos, R. Building a community to support HS CS teachers: the disciplinary commons for computing educators. In *Proceedings of the 42nd SIGCSE technical symposium on Computer science education* (Dallas, TX, USA, 2011). ACM.

[7] Ericson, B., Guzdial, M. and Biggers, M. Improving secondary CS education: progress and problems. In *Proceedings of the 38th SIGCSE technical symposium on Computer science education* (Covington, Kentucky, USA, 2007). ACM.

[8] Wilson, C., Sudol, L., Stephenson, C. and Stehlik, M. *Running on Empty: The Failure to Teach K–12 Computer Science in the Digital Age*. <http://www.acm.org/runningonempty/fullreport.pdf > Association for Computing Machinery & Computer Science Teachers Association, 2010.

[9] Davis-Unger, A. and Maring, B. L. Disciplinary Commons: Brief Summary. <http://depts.washington.edu/comgrnd/leaders/OEADiscCommonsEval09.docx> , University of Washington, 2009.

[10] Maring, B. L. and Davis-Unger, A. Disciplinary Commons Follow-Up Survey Evaluation Report. <http://depts.washington.edu/comgrnd/leaders/DiscCommons_FollowUpSurveyReport_FINAL.docx>, University of Washington, 2010.

[11] Davis-Unger, A. and Maring, B. L. Disciplinary Commons 2009-2010 Evaluation Report. <http://depts.washington.edu/comgrnd/leaders/DiscCommons_2011_EvalReport_R1.pdf >, University of Washington, 2011.

[12] Ni, L. Building professional identity as computer science teachers: supporting secondary computer science teachers through reflection and community building. In *Proceedings of the seventh international workshop on Computing education research* (Providence, Rhode Island, USA, 2011). ACM.

[13] Ni, L. and Guzdial, M. Who AM I?: understanding high school computer science teachers' professional identity. In *Proceedings of the 43rd ACM technical symposium on Computer Science Education* (Raleigh, North Carolina, USA, 2012). ACM.

[14] Cross, J. E., Dickmann, E., Newman-Gonchar, R. and Fagan, J. M. Using mixed-method design and network analysis to measure development of interagency collaboration. *American Journal of Evaluation*, 30, 3 2009, 310-329.