BUILDING AN OPERATING SYSTEM FOR
Computer Science Education

STORIES FROM THE FIELD

"Stories from the Field" shares the experiences of people from four communities who have acted locally to advance computer science education nationally. The sites represent a range of locations, institutions, and strategies that demonstrate some of the different pathways others can take to further computer science education in their own communities. University faculty, curriculum developers, district administrators, teachers and others share their perspectives, their successful strategies, their biggest challenges and offer insights and recommendations for others.

In April and May 2013, researchers interviewed 3-7 individuals per site. The interviews began with a single, primary leader who then recommended others to participate. Researchers also reviewed effort artifacts and on-line resources.

Chicago: District Partnership

Georgia: Expanding Over Time

THE UNIVERSITY OF
ALABAMA

University of Alabama: Leading State Change

PURDUE
UNIVERSITY

Purdue University: Preparing Teachers

CHICAGO: DISTRICT PARTNERSHIP

In 2008, a group of computer science teachers decided to change the computer science offerings available for Chicago students. Through the experience of trying (and failing) to secure NSF funding to support their effort, the group built and maintained relationships with district leaders, university professors, and teachers. The group also learned valuable lessons on how to make such a wide-scale effort happen, including finding instructional materials that met the needs of a large urban school district, and ensuring that all stakeholders' needs and concerns were represented in their plan. Ultimately, they learned that a truly committed group goes a long way toward accomplishing goals, and they cite this attitude as the primary reason for their success. After submitting their third proposal, the group was awarded NSF funding. The resulting program, Taste of Computing, will reach over 1800 Chicago high school students by Fall 2013.

PEOPLE

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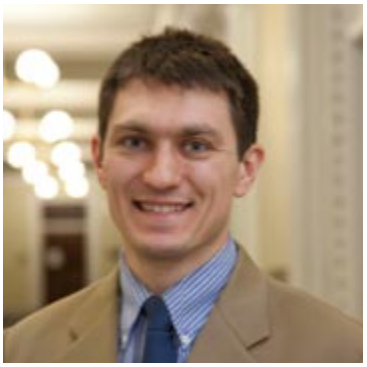

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Don Yanek
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2008
Portland, OR
Yanek, Solin, Franke, and colleagues committ to increasing CS participation in Chicago high schools at SIGCSE
2009
Chicago, IL
Chicago CSTA chapter formed; first NSF proposal submitted by Chicago group.
2009
Los Angeles, CA
Chapman and colleauges finish 2nd edition of ECS
2009
Chicago, IL
Yanek attends CSTA leadership PD led by Chapman. Yanek recieves 2nd edition of ECS from Chapman
2010
Los Angeles, CA
Yanek, Solin, Reed participate in ECS PD led by Chapman. Greenberg contributes funding for travel
2010
Chicago, IL
Wilkerson tasked with revamping CPS CTE program
2010
Chicago, IL
2nd NSF proposal submitted by Chicago group
2011
Chicago, IL
Third NSF proposal submitted by Chicago group
2011
Chicago, IL
Chapman leads CS4HS PD for Chicago teachers
2011
Chicago, IL
Taste of Computing funded by NSF
2012
Chicago, IL
Taste of Computing begins in CPS STEM schools and CTE programs
By Fall 2013
Over 1800 students
and 75 teachers

HISTORY

A Grassroots Effort: The Chicago story surprisingly begins in Portland, OR, at the Special Interest Group for Computer Science Education (SIGCSE) conference in 2008. A group of computer science teachers, including Don Yanek and his colleague Jeff Solin, computer science teachers at Chicago's Northside College Prep sat in a room together. Jeff Solin stood up and said that they were from Chicago and asked if anyone could help them. In the same room were others that would eventually become integral to the Taste of Computing effort, including Gail Chapman, an author of the Exploring Computer Science (ECS) curriculum, and a leader of ECS professional development. She also provides support to districts interested in implementing ECS. Baker Franke, a computer science teacher at the University of Chicago Laboratory School, was also at the SIGCSE conference, and became part of the Chicago group.

Each of the original team remembers that moment well. Don Yanek explains:

> *I guess it really started out of a need in terms of our local school; we were experiencing dropping enrollment, and at one of the SIGCSE conferences, my coworker Jeff stood up at this panel discussion which was talking about the current landscape of high school CS education and the fact that programming is disappearing across the nation and enrollment was at an all time low. He stood up at this meeting and talked about our school, it's a higher performing school, for gifted students, and we're experiencing the same problems, and basically made a plea in this large conference room -- is there someone who would be willing to help us or talk to us about it? And in this audience of a couple hundred people, a gentleman stood up in the back and said "I'm from Chicago, I teach at -- let's talk after this".*

Gail Chapman also remembers:

> *I actually was in the same room with Don Yanek and a couple of other people from Chicago at a SIGCSE conference presentation when they discovered each other. I didn't know them; I just knew that they were interested in doing something in Chicago, and our lives were on parallel tracks because it was exactly the same time that I started working on Exploring CS curriculum.*
>
> *Trying…and Failing: Upon their return to Chicago, Yanek, Solin and Franke joined forces with Dale Reed, a professor at University of Illinois Chicago (UIC). The first step the group took was to create a Chicago chapter of the Computer Science Teachers Association (CSTA). The group also wanted to increase computer science offerings in Chicago schools. To that end, the group, now including Loyola professor Ron Greenberg, submitted two NSF proposals to fund wide-scale change in Chicago. Neither the first proposal, submitted in 2009, nor the second proposal, submitted in 2010, received funding. They concluded that part of the problem was that they didn't know exactly what they would do.*

Baker Franke explains how the group realized they needed a curriculum:

> *Our initial plan was get a bunch of teachers to talk to a bunch of principals to generate something, so that eventually someone on top might say hey, what are all these principals complaining about, all these principals have all these teachers who are saying they need computer science, what the hell is that. That was sort of the plan. Somewhere in there, we decided, what if someone says yes? Right. What is our plan? And part of the reason no one, people said oh that's a really interesting idea, what do you want to do? We didn't have an answer. We couldn't say here's a curriculum we're going to teach, and we're going to provide all the training for all the teachers. We didn't have that, we didn't even know that that's what we were supposed to do.*

The Ideal Curriculum: While Reed, Yanek, and their colleagues were writing and submitting proposals, their experiences in the computer science community helped shape their understanding of how to bring more computer science to Chicago. In 2009, Yanek participated in a CSTA leadership workshop led by Chapman. Chapman and her colleagues in Los Angeles had just finished writing the second version of ECS, and sent it to Don after he mentioned that he was looking for a CS curriculum to implement in Chicago. A year later, Yanek, Reed, and Jeff Solin, traveled to Los Angeles to experience ECS for themselves, via a professional development workshop led by Chapman.

Dale Reed explains how different the ECS professional development was from what he and his colleagues expected:

> *Three of us, myself, Don, and Jeff Solin went out to UCLA. Part of this was funded by a travel grant from Loyola, so there's partnership at work there. We went out there, participated in the PD, 3 or 4 days, and Don and Jeff have been in a lot of PD sessions before, started to do the drill, sit there, pretend you're interested, it's boring as anything, you look at your watch and hopefully by the end of the day you get to go home. Well, this is not like that at all. We couldn't believe how much fun it was, and time just flew; when they said the day is over we were disappointed; every day we were looking forward to getting back into it, it was really great, compelling, exciting, we were really excited about it. We came back to Chicago determined to try this as a model for a new CS course in Chicago. So we started thinking about how to do that, so we started spreading the word."*

Don Yanek explains how ECS curriculum is inclusive and accessible for all students:

> *…The great thing about the curriculum is that it has a low floor, so there's an entry floor for every student no matter what their experience level is, and how comfortable they are using a computer. There are wide walls, so there's room for everyone to contribute, and there's a high ceiling, which means it's going to be challenging for everybody, they're going be*

challenged in the curriculum. So the idea of starting with human-computer interaction and one of the things that drew me to the curriculum in the first place is that for the first 8 weeks of the curriculum you don't have to use a computer at all.

Baker Franke was also struck by the inclusiveness of the ECS curriculum:

The ultimate goal of the Exploring Computer Science curriculum is to make every student in the room feel like, not only feel, believe, and actually have, a stake in their learning, and in the field of computer science. Everyone has a voice. Everyone can contribute. Because the curriculum was developed based on the Stuck in the Shallow End research which said, look, anybody's who's not a white or Indian male in these classes, even if they take the risk of taking the class, they're sidelined because it's not part of their culture, their social group, their belief systems around what computer science is, the teachers' belief systems around what computer science is, and who is talented at it, or gifted, who gets it and who doesn't. Those are so ingrained that that's why computer science is a turnoff. The research question for Stuck in the Shallow End is why don't students, especially women and students of color, 'choose' to take computer science, even though the course is offered. Why aren't they in there? Well it turns out it's not just about having access to the course, it's about other things. So that's a serious meta-layer on what we're trying to do, we're not just trying to teach computer science, we're trying to make sure every kid in the classroom has a stake.

Identifying a Need: After two NSF proposal rejections, the Chicago group looked for "ins" with Chicago Public Schools (CPS) that could lead to increasing CS education opportunities in Chicago. At the same time, the CPS career and technical education (CTE) program was being revamped, led by Brenda Wilkerson of CPS. The group recognized that CTE would be a good doorway into CPS and partnered with Wilkerson to tailor the ECS curriculum to the needs of the Chicago public school system. CPS required Microsoft Office certification as an outcome of their CTE pathway, and the group was able to customize ECS curriculum to include material on Microsoft Office. This allowed ECS to become CTE's foundational course.

Wilkerson on the ECS curriculum:

When I found out about LA and Jane Margolis and Gail Chapman, before I met them I listened to several speeches they had given; I was so inspired by the thought process that they had gone through to reach the conclusions that came up with the curriculum. It wasn't "oh, let's try this," it wasn't about "let's do this for this small group of students," it was specifically about our demographic; it's the same demographic, it's the same mammoth of a school district, all the political issues, all the demographic shifts, things that we faced. So to me that gave the curriculum more of an emphasis for us to look at.

Third Time's the Charm: The group, now including Lucia Dettori, an Associate Dean at DePaul University, submitted a third NSF proposal, this time with a course and a plan in place. They made up their minds, however, to accomplish their goals with or without the funding. Lucia explains,

> *So then when we did have that final grant application, we were able to say, "if you give us the money, we'll be able to do it better and faster, but we're already doing it and we're going to continue to do it." So I think that's the other part, to not look to NSF to solve our problems, but we have to think, what is the right thing to do in Chicago? Really just from a moral and a justice perspective. What is the right thing to do, and we have to be committed to doing it for us, the teachers and CSTA, regardless of what happens with the funding. So we started before the funding and I think we'll continue after the funding for that reason.*

Brenda Wilkerson also remembers the powerful attitude of conviction held by the group after their third proposal was submitted.

> *…It was one of those things where we looked around the room at each other and said "if we get this money, we can do wonderful things with lots and lots of teachers, but if we don't get this money, we're doing it anyway. We're going to figure out how to do it." And it seems like that attitude is what got us the money this time. Before it was like we need the money, we need the money, and then we said no, this is something that the time has come, let's do it.*

The NSF grant was funded, creating A Taste of Computing – a modified ECS curriculum specific to the needs of CPS.

Taste of Computing Today: Today, with the support of NSF funding, the effort is at a new beginning. Taste of Computing is the foundational course for the CPS CTE program, which is present in 35 high schools. Taste of Computing is also taught in the CPS STEM schools. There are nearly 900 students enrolled in the STEM school Taste of Computing course, with another 900 scheduled to enroll for the 2013-14 school year. Nearly 75 teachers will have participated in the ECS professional development by the end of summer 2013.

SUPPORTS AND STRATEGIES

Stakeholder Representation: It became clear that making sure everyone's needs were addressed was essential. It was important that each person's unique resources and viewpoints were able to synergistically contribute to moving the effort forward. Having university people involved, such as Reed, Greenberg and Dettori, allowed them to assure school and district leaders that students with computer science experience was something that universities desired. Teachers such as Franke, Yanek and Solin were able to provide input on the needs of other computer science teachers. District people, such as Wilkerson, were able to understand and articulate the needs of the district, and communicate the desires of the group to other district leaders.

Yanek explains it this way:

> *Build a coalition of stakeholders in your community, people from every group. When I look back at the success we've had, it's been because we've had somebody in our group that represented some individual stakeholder. We got the university teachers that are involved, we have somebody at the board of education, in CTE, that is really involved, and then we have our group of high school teachers, our pilot teachers as well as some of our CSTA members that are really energized. So having a broad coalition, somebody that can speak to each constituency is important.*
>
> *Group Commitment: The Chicago group decided that they would make a change happen in any case and it was this attitude that carried them through to earning the final grant. Each member of the group worked to achieve the goal of bringing ECS to Chicago outside of their day jobs, and leveraged all of the resources available to them to accomplish this. Having support for the high school CS teachers through the CSTA was also critical in an environment where many were the only CS teachers at their school.*

Lucia remembers how this drive and commitment helped them preserve:

> *…When the second one was not funded, we grouped with the bad news around the table at Northside College Prep and we said "can we make a pact that this is too important to wait for someone in Washington to bless us? And can we just make it happen." We were determined after this second proposal was not funded to make it up somehow.*

Lucia also cautions that you need a coalition of diverse stakeholders:

> *It is very important to have a champion of your cause. One person that is in your team, in your core, committed, that's not going say "this could be a solution, but I don't know..." Someone that really gets it. Unfortunately that's not enough, so I think you want to try to diversify and have contacts at different levels in the district.*

University Support: DePaul University provided logistical support and facilities as well as credit for teachers. It was critical to the Taste of Computing effort to have a large central location that could accommodate teachers for professional development. Professional development is a critical component of the ECS curriculum. Terry Steinbach of DePaul University was responsible for the logistics of the ECS PD and she explains some of the benefits to the teachers of partnering with a university.

> *…Also we offer participants for the summer, if they attended all five days and stayed all five days, then they could receive two semester hours' worth of credit, and if they attend all four of the PDs, they get another credit hour, at no charge to the participants.*

Appropriate Instructional Materials: The Chicago effort focused on working within the district system, which necessitated quality foundational instructional materials. ECS served that purpose while also addressing the issues of a large, urban school district

As Brenda Wilkerson explains, it was critical to find examples of curricula in other large cities to know that the same challenges could be addressed.

> *It's the same beast and the same size, and we're smaller than they are, so I thought we get to be the little sister this time instead of the big sister. Normally people look to us and go, 'wow, if it works in Chicago then we can do it!' So I looked at LA, and said 'if it works in LA, it's something that should work for us, so let's give it a try.'*

CHALLENGES

Scale and Communication: Large urban school districts present unique challenges of scale and communication. CPS is one of the largest school districts in the country, and it is difficult to make widespread change because of the complicated nature of such a system.

Gail Chapman explains how the diversity of teachers and their school environments, combined with the large size of the school district, can present challenges for growth:

> *PD and teacher learning is a process, and good teaching never rests. You have to constantly grow and change, and so I think there's just -- none of the challenges were unexpected; they're all normal, no matter what the size of the population is, it's just that because there were so many, we didn't have that core advocate group in place yet, other than the leadership team, who don't all share characteristics that the majority of the teachers have. This is one of the things that we're working to change, which is to get some of the teachers that are currently teaching who are in more challenged school environments to be part of the leadership, because it's evident from me observing classes that this works in the schools for which it was originally intended, not just the Northside College Preps. But teachers need to believe that, and they don't necessarily completely believe it. So the more teachers we can get that are in challenged environments, being leaders and speaking up, the more likelihood of continued success there will be.*

Appropriate Instructional Materials: It was challenging for the group to find a curriculum that would address the unique needs of CPS, including goals of equity and access, and the possibility of customization to meet the needs of the district. Brenda Wilkerson explains the importance of finding a good fit for your district:

> *So you just have to take a look at your environment and figure out how change is made. And then go after it that way. Don't carbon copy what someone else does, because it may not work that way in your environment. It doesn't mean it won't work, it just means you have to figure out who are the stakeholders, and how do you institute change.*

Finding a Place in the District: Initially, the group tried to convince individual principals to add their CS course to their schools. This piecemeal approach proved difficult. Fortunately, CPS was revamping their CTE pathway and adding new STEM schools to their district. This created places for the CS course to fit into the school day across the district. It seems likely that the group would have had a much harder time impacting as many students if they had to convince each principal to include the course at their school.

Teacher Communication: One challenge common among computer science teachers is that they are often the only ones in their schools. This, coupled with the large, sprawled nature of Chicago public schools, contributes to challenges of staying connected. It has proven difficult for the PD providers to stay in touch with the CS teachers, and for the CS teachers to stay connected to each other, and rely on each

other for support in-between PD sessions. Baker Franke explains how he might keep teachers connected if he could start over:

> *We never assigned that task, a community maintenance task. It was added on to someone, made a website, that no one really uses. So maintaining not just the community, but a pool of resources that teachers develop including things like the PD agenda and pictures from the PD. Because at the PD, a lot of people say 'oh I have a really good thing that I use for that,' how do you actually get it, how do you collect that? If I could do it again, that should be someone's major task. It's just to maintain a community, a growing community of teachers and nurture them better.*

ADVICE FROM CHICAGO

Build Trust and Community: Take the time - years, not months - to make real connections in your community and build trust, both in planning and in the professional development itself. It is crucial to have a clear understanding of the common goals of stakeholders. Everyone involved should feel as though they are part of a community and know that they are supported.

Gail Chapman explains the importance of community building and addressing the needs of stakeholders:

> *The first thing that I would tell people is get your partners together and decide what your goals are and make sure everybody has the same goals. One of the things that I think made what we did in LA to start with somewhat unique, and it's what has carried on into Chicago and the other places that are so far funded to do ECS, is that partnership between the university and the district and often other partners as well, but including district personnel as well as teachers as well as the university faculty so that it's not someone coming from on high and saying "this is what you must do." Often university faculty don't understand what's going on in the school district; they don't understand the needs of the district, and when they go say "we're going to do this" they miss the boat entirely, because it turns out the district needs X. We had to navigate this whole Microsoft certification issue in Chicago. It existed; we did not have a choice but to navigate it or not be there, so how do you do that? And what goals do you have? In this case one of the goals was to recreate CTE in Chicago and recreate it with a better foundation. It turns out that was a very synergistic goal, but there was also the -- the district has this group of needs related to that, and these schools in mind, and the university has these schools in mind and these sets of goals; how do you bring those together in ways that end up being good for kids?*
>
> *We really need to be very, very strict about allowing enough time, especially in that first summer, to do the community building, to do the reflection, make the connection, because then they go back to their classrooms and the doors close and what happens now? There needs to be some level of comfort that if they struggle, there's somebody they can go find.*

Reach out to Others: Others may be struggling with the same issues that you are. It only takes a small number of people bringing their resources, expertise, and experiences to the table to make big changes happen. When asked what advice he would give to others, Don Yanek explains:

> *I guess it would be get out of your local environment, go find out what other people are doing. Ask for help, ask questions, because they may be in the same situation wondering I really would like to change things but I don't think there's anyone else that's interested in change and you'll find there are other people. And it really just takes a small number. For us it*

started with just 5 people. I think of my coworker just standing up at this meeting and saying "is there anyone here that wants to work with us?" and there was. Just from that simple request, I like to say that we're involved in systemic change in the CPS, that ultimately will affect thousands of students, tens of thousands

Be a Salesman: To convince the district that ECS was the right choice for a foundational CTE course, the group had to sell the course to district leaders. Here, the representation of all stakeholders worked in their favor, since these stakeholders were able to explain to district leaders why the ECS program was a good fit not only for the district, but also for the larger community. Brenda Wilkerson explains the finer points of being a salesman:

You have to sell it, but you have to sustain the sale, and you sustain the sale with a variety of different things. Don't hit them with everything all at once, hit them with it gradually, and use your university partners for that and use your corporate partners for that and grab those students who've gone through the program and have wins, and make them poster children.

Find Logistical Supports: In any case, holding PD for groups of teachers requires space, food, and logistical support. For the Chicago group, these came in part from DePaul University. As Lucia Dettori explains, logistics must be considered:

One advice is, PD costs money. So our time is free, with some of us, but that would not be the issue, we would do this anyway. Feeding people for a week costs money. So find a way to find the basics. Parking downtown, $14 a day, costs money, times 30. So there are some things that even if you have the best intention will cost money, room and things like that, so that's something. In terms of making it worthwhile, it's critical to have a team of people that involves not just high school teachers, not just faculty from schools, you really need to have a variety of people that are committed to the cause. There need to be high school teachers, there need to be faculty from schools, some administrators; we do not have representation from counselors, but I think for the PD it's not critical, but these would be people you'd want to fold into your PD; otherwise it's very difficult to recruit students. Timing. I'm going to be very practical; you've got to put your dates out there months in advance. Everybody gets busy in the summer, so it's very difficult to get last minute commitments. Follow-up PDs are proving to be harder; attendance is not as good as we would like.

Build Real Relationships: The relationships built over time by the Chicago group were crucial to their eventual success, and will continue to be crucial as the effort evolves and scales.

When asked what the biggest challenge in CS was, Gail Chapman explained:

Trying to keep the folks who want to scale yesterday under control. Seriously. There's a lot of momentum right now, a lot of folks that feel that online is the answer to everything; we'll just put PD online and life will be good. We'll go directly to the students, teach them to code, and life will be

good. You don't want to dampen enthusiasm, but at the same time, you want to channel that enthusiasm in appropriate ways. So, for example, online can be really good for some things. But it can't substitute for face-to-face on the ground connected to teacher classroom stuff. So how do we balance that, how do we manage the enthusiasm in ways that both help us to scale things that are hard to scale, like mentoring for example. We can't have face-to-face mentors in class every day. That's not sustainable or scalable, so how can we leverage online tools to do those kinds of things perhaps, while saving the things that need to be face-to-face and connected to local community? And still scale. Scale smartly.

Be Open to Improvement and Reflection: Gail Chapman explains some practices of teaching that she considers crucial to the ECS curriculum:

People ask all the time, "what are the qualifications for an ECS teacher?" and my number one qualification is that this person is reflective about the practice of teaching. Because if they are, then all this other stuff can come; if they're not willing to acknowledge that perhaps they have something to learn and work on that, then it's going to be really tough, no matter how much content knowledge they may come with.

VISION FOR THE FUTURE

Change the perception that CS courses are only for students that want to become computer scientists: When asked what her vision for the future of CS was, Brenda Wilkerson said that she hoped to see a change in the perception and culture of CS. When asked what that would look like, she explained:

> *The culture is when CS is respected as a discipline, that it's something that is college prep, and yet it's something everyone can do. And that whether or not you're going to be a programmer, you still would benefit from CS education. That's the big shift. It's okay that I took for years of chemistry in high school; I was pre-med at the time, but you take four years of chemistry, you take AP chemistry, and you may never be a chemist; there's no assumption that when a kid takes AP chemistry, that he's going on to be a chemist. There's no assumption that when I took all the AP Englishes, that I was going to teach English, or become a poet, or whatever you do with that stuff. I love Shakespeare, got the whole segment, never used any of it in my jobs. That's okay, I don't feel it was a loss, I feel like I got something from being culturally literate in Shakespeare. We don't have the same attitude about CS yet, the culture doesn't say, oh you can take this and this is valuable, they say oh, you're not going to be a programmer, so why would you take that? So the culture has to come to say, this is a normal part, a critical part of literacy. So in the buildings where that is true, we thrive.*

Integrate computer science into other disciplines in the classroom, and begin CS experiences earlier in student's school lives: A potential way of sidestepping the issue of finding a place in the school day might be integrating CS into other subjects. This might also lead to rich, substantial CS experiences earlier in the lives of students.

Dale Reed explains how CS experiences might be integrated into students' lives earlier and more often:

> *I think there are pieces of computer technology that are accessible and relevant to what teachers such as language arts teachers are doing in the classroom, so that it should be used starting in elementary school. Not necessarily as a main separate topic, but certainly by middle school, kids should be using something like Scratch. And having significant programming experiences, because in our lives, technology is the interface with which we connect to information and other people, and we want to be able to control the technology and not the other way around. This is of critical importance to our kids. I think it should start in elementary school, definitely by middle school, it could be something that's clearly defined, and certainly in high school, and this is my mission for us in Chicago -- every high school student should have a compelling experience with CS and understand what the field is before they graduate. How can they choose it when they don't even know what it is?*

Increase participation in CS for all students: To meet the country's needs for skilled CS workers, all students must necessarily be engaged and invited to participate in CS. As Don Yanek explains, this issue cannot be left out of conversations about the future of CS education:

> *we still need to be talking about how do we get all students involved, no matter what their gender or their ethnicity, and that we have students coming from a variety of backgrounds and we need to make sure that all of them are welcome and that they all feel that they have a place in the classroom and that they can all contribute. I think that's a very important conversation that we can't leave out.*

Gail Chapman explains her vision for how CS education could include all students:

> *In five years, I would like to see every student have access to real CS in schools. Notice I didn't say required, notice I didn't say it was necessarily a core subject, but I want all students to have access to such a course. That's got to be the -- I don't want to be cynical here, but I think that... there are some realities that we need to just keep in our minds in terms of the way schools work. Short of overhauling the entire school system, we're not walking into a school district and saying "you have to offer CS instead of art," or "you have to offer CS instead of calculus." That's not going to win. I think we think that CS is totally unique in that if you go to conferences where there are people who are in arts or people who are in engineering or music or pick your random subject, anyone who's not part of the core is fighting for the same piece. And while I think that CS is really important for students to have in the 21st century, I'm not sure I can argue that it's more important than something else for some students. But I want all students to have the choice, and I want all students to be welcomed and find a place in a CS course. If we do that, then I think the demand for the courses will be such that it will do as much for helping the problem as a lot of the policy things might do. Not that people shouldn't continue to work on policy, but I think we have to recognize when we're winning battles and continue to win those battles and not throw the baby out with the bathwater, not be so hell-bent on computing in the core that we lose sight of here's an opportunity over here, where it's an elective but we can get it in.*

Leverage success in large urban areas to raise the importance of CS education across the country: As noted by Wilkerson, successful programs in Chicago can inspire others to attempt similar efforts. Baker Franke hopes that changes in CS education in Chicago, Los Angeles, and other large urban areas, will inspire others across the country.

> *That would be my hope, that in five years, that these implementations in Chicago, LA, NY, DC, that we could have some publicity, maybe it's generated from some published report or some series of presentations or PR campaigns, saying that these schools have changed CS education, you should too.*

UNIVERSITY OF ALABAMA: LEADING STATE CHANGE

The state of Alabama is a pioneer in the effort to expand and improve computer science education for students. With many partners and collaborators, Jeff Gray, an associate professor in the computer science department at the University of Alabama, leads a variety of initiatives for students and training opportunities for teachers on various topics including robotics and AP CS Principles.

PEOPLE

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Consultant, A + College Ready

Dr. Elisabeth Davis
Assistant Superintendent for Curriculum and Instruction at Tuscaloosa City Schools

HISTORY

Currently an Associate Professor in Computer Science at the University of Alabama, Jeff Gray is one of the champions for computer science in Alabama. He began outreach in computer science education in 2004 when he ran a computer science summer camp for high school students. He continues to lead camps for students as well as a variety of professional development opportunities for computer science teachers. Gray worked with many collaborators and partners to make his efforts in computer science education a success, including Carol Crawford, Amber Wagner and Dr. Elisabeth Davis. Some of the efforts that Gray and his colleagues worked on include:

Robotics Initiatives: In 2011 and 2012, Gray led one and two day robotics training workshops for middle and high school students. To get this robotics program started, Gray approached the superintendent of Tuscaloosa City Schools. After speaking with Gray, the superintendent wanted to bring robotics to his schools. They sent out invitations to all Tuscaloosa City Schools to participate. Elisabeth Davis, the assistant superintendent of Tuscaloosa City Schools, said that the district's relationship with the computer science department at the University of Alabama had not always been productive. She said that from the district perspective, there was little understanding of the importance of technology. With a new superintendent, this changed.

In 2012 and 2013, Gray and his team visited nine elementary, middle and high schools to teach robotics. In robotics trainings for teachers, which are usually for teachers with no previous experience with robotics, teachers learn through both instruction and hands on experiences with the robots. Elisabeth Davis said, "[The teachers] said that [the robotics training] was great, the whole day of PD was hands on, they enjoyed it, that they learned a lot, and they had no idea that this was a lot of what CS was." Gray and his PhD student Amber Wagner also shared robotics lesson plans with teachers.

Amber Wagner on robotics:

> *A couple years ago when we first started we worked with the local magnet school and we taught two different elementary classes once a week for six to eight weeks, and we were there for a whole class period. We would teach them for the whole class period and they did really well and went on to compete in the robotics competition where they did well. We also did a teacher workshop that semester where we had a whole day where a bunch of teachers came in, we showed them how to use the robots, we sent them home with a loaner robot that they could play with and use in their classrooms. Dr. Gray did something similar last year and then this year, this spring, to ramp up for the competition, we went out to probably eight schools once a week for a class period for six weeks.*

AP CS Principles Initiatives: Gray recently received funding through the National Science Foundation for a three-year project to bring CS Principles to 50 schools in Alabama. Gray views this as a crucial effort as only three schools out of 460 schools in Alabama offer AP computer science. Alabama is the first state to list CS Principles on the state's Department of Education list of official approved courses. Alabama's new state superintendent was very supportive of this course and wrote letters of support for the course to be added to the list of approved courses.

Gray collaborates with A+ College Ready, which is the National Math and Science Initiative (NMSI) partner that is working to expand advanced placement course offerings in Alabama by offering professional development to teachers. In the summer of 2013, Gray and A+ College Ready will offer training in AP CS Principles for 11 teachers who will serve as mentor teachers to newly trained CS teachers in 2014 and 2015.

Gray recruits teachers to participate in his efforts through the Computer Science Teachers Association (CSTA) and the Special Interest Group on Computer Science Education (SIGCSE) mailing lists and personal connections. The Alabama Department of Education helped reach a broader audience of STEM and career tech teachers.

CS4HS Workshops: Gray and his team offered CS4HS teacher workshops at the University of Alabama in 2011 and 2012 and will offer another workshop in the summer of 2013. They hosted 15-25 teachers at these workshops. The workshop presents tools such as Greenfoot, Scratch, BYOB, Alice and Lego Mindstorms. They also discuss AP CS courses and do some CS Unplugged activities.

Summer Camps: Gray and Wagner, along with Jonathan Corley (a CS PhD student at the University of Alabama) will teach middle school and high school computer science camps this summer (2013). Topics include game programming with Scratch, programming with Java, App Inventor and Robotics. Learn more about these summer camps.

SUPPORTS AND STRATEGIES

Partners have provided vital financial and motivational support: Gray and his team at the University of Alabama have partnered with the National Math and Science Initiative (NMSI), UTeach, and local schools. Exxon-Mobile as well as other large companies funded the State of Alabama to increase the presence of AP education specifically. Gray also has support from Google's CS4HS program and mentioned that this support was helpful in laying the groundwork for his current NSF proposal to train teachers to teach CS Principles. The University of Alabama also provides Gray with facilities. Chris Stephenson, the executive director of CSTA, as well as Tim Bell (the founder of CS Unplugged) gave talks at Gray's schools and at the McWane Science Center in Birmingham, Alabama, which increased interest in computer science. One of Gray's main collaborators is Carol Crawford at A+ College Ready. They collaborate on the current NSF grant to train 50 new AP CS Principles teachers.

Davis on working with the University of Alabama as a partner:

> *It's a great partnership, it's also a way to get the University of Alabama name out to kids at a young age. It also gets kids ready for whatever they're going into because we've been told by the University specifically that our kids aren't ready – that they don't have the general math skills, but beyond that they don't have the problem solving skills. Working as a team, collaboration, teamwork and higher order thinking skills- our kids don't have them and our teachers don't know how to teach them, and they don't realize they're doing that they do learn those skills through this type of program. So it's a win/win for them, but it's a win/win for us. The University comes in and provides the training, the support and the competition.*

Personal connections with local teachers: Gray has direct connections with every AP CS teacher in Alabama. He said that these personal connections help to network across the state. Gray says,

> *It has to come back to the teacher, so none of this survives if the teachers don't have the passion to take the things that they see and integrate it into their own curriculum.*

Selling CS to local school districts: In the case of Gray's K-12 robotics training, he approached a local superintendent who was enthusiastic about the idea and sent out invitations for his schools to participate. Davis said,

> *Our superintendent is very supportive, our CSFO (Chief School Financial Officer) is very supportive. He is just excited that we finally have computer science in our system." Gray described his work as acting like a "door-to-door salesman." He visits 20 high schools and middle schools per year*

and presents slides that introduce students to CS and information about CS careers.

Grassroots efforts to get students (and their parents interested in CS): Gray described the importance of increasing student and parent interest in computer science to further his efforts. He said that this interest often gets the attention of administrators. To get the attention of students, Gray visits about 20 schools per year to do a 45-minute to three-hour presentation. He shows students how to use App Inventor to create an app that controls a robot. He said,

> *If you have a lot of students that are on the edge of their seat trying to understand how that works, and it's real understandable, it's not magic, it's something that's easy to do, and then they want to know more.*

Gray on grassroots efforts:

> *About ten years of knocking on doors, there have been two strategies. When you find your superintendent and can get your foot in the door there, and you find someone really open, that's an easy sell. If not, I would go straight to a grassroots effort, and it was not deceptive but I was trying to go from the bottom up. Get the students interested which drives the parents, and then once we did that we got invited to a PTA meeting and then we got invited also to the board of education for that school's monthly meeting and we were able to talk a little bit about that. So in that case it's driven from the bottom up. Teachers or students start to demand this or start to get excited about it and that drives the administration to take note. So that's been one tactic, and even in Birmingham there's two school systems that are rivals, and we'd go to one and say "hey, we just spoke to so-and-so," and then go tell the other, and they immediately wanted to do the same because they can't have the other one get one up on them. So using a competitive approach to get them going, but it's either top-down if you've got the superintendent or the administration knows what they're talking about, or you have to do bottom up if you're in a school system that the administration is nodding their head yes but not taking any action so you need to from the populace get that going.*

Formal agreements: To address the issue of a lack of teacher engagement, Gray asks teachers sign a formal agreement that they will remain engaged in the program and in some cases, even lead the program after a few years. Gray explained that many grants require this kind of commitment and this kind of agreement helps make sure that teachers are invested in the program.

Use your resources: Gray and Wagner mentioned the value of several computer science organizations including Code.org, CSTA, NCWIT and SIGCSE.

Offer engaging professional development opportunities for teachers: Crawford discussed the importance of designing professional development for teachers that is both useful and engaging. She spoke about plans for an upcoming professional development experience to train AP CS Principles teachers.

Crawford on PD for teachers:

> *I'm envisioning a good part of the time will be spent in the teachers actually developing lesson plans, developing projects, and implementation strategies so that at the end of this four days we at least have a scope and sequence and some lessons that they'll be able to take back to their classrooms and implement immediately. We don't expect it to be all Jeff and others delivering and them listening. We really want to get the teachers actively engaged in product development. We have asked them to work with us during the rest of the summer to -- not face-to-face, but to pick out something that they feel really comfortable with and do some homework assignments focused on developing additional materials. We will bring them back during the school year for two more days to ask, okay, what did you teach? How did it work? What do we need to tweak? We will move on to maybe the next nine weeks of the course in that two days. We don't think our PD goals can be accomplished in a four-day time frame. We will continue to work with our teachers through webinars and talking with them through Google hangouts, we also want to use the Community of Practice that's part of the CS10K project. With A+ College we have either content specialists on staff with us or teachers that have proven to be very good in their craft, serve as mentors to other teachers. So this first group of eleven teachers we are grooming them to take that role with the next 40 teachers that we bring on board. So they're going to be our whiz kids and master teachers as we build the CS teacher ranks.*

Capture student interest: Wagner spoke about how students believe in stereotypes about people who study computer science and feel that taking computer science courses is not for them. Wagner believes that showing students how computer science can be exciting is a good strategy for overcoming this stereotype issue.

Wagner on student interest:

> *When we go into the schools, I think there's a problem with getting the kids over the stereotype that CS is not cool, that it's somebody sitting at a computer by themselves all day every day. Getting them over that stereotype, but it's kind of a good thing about robotics, once they get that robot in their hand, they start playing with stuff, those kids get so excited. I've seen these kids, they walk in the classroom like they're really really cool, especially the high school students. They're cool kids, and they want to act like it's no big deal, and then they get the robot and there's smiles and they're talking and they're asking questions and they get really into it.*

Provide teachers with computer science teaching resources: As a prior teacher, Wagner realizes how busy teachers are and how little time teachers have to plan classes. She said,

> *If [teachers] have to build a whole new course from scratch, create all the curriculum themselves, that causes them issues, some hardship. One of our goals is to connect them with other teachers and with existing curriculum to save these teachers some development time.*

CHALLENGES

Lack of sustainability: Gray explained that once funding of a program ends, the program can be in danger of ending. He said that it can be a challenge to involve teachers in the program in a consistent way.

Gray on sustainability:

> *Sustainability has always been the challenge. And then just finding the kind of teacher you need who has that excitement and passion as well and doing it for the right reasons. That's been the main challenges. It's kind of frustrating when you know that we can only do this two or three times per session, so we do it for two years, and we hope the teacher will take over, but if they're back grading papers and not paying attention and we have no mechanism to bring them up and engage them, that's the main challenge.*

Balancing Responsibilities: Gray has many responsibilities as a professor at the University of Alabama. His challenge is to balance a teaching load and working with PhD students with his outreach efforts. He said,

> *My challenge is I have to wear two hats, find a way to scale this [effort in computer science education] even further and also keep my research pipeline going. This all started as a hobby and just took off.*

Gray will run three computer science camps for students in July as well as two training sessions for teachers in June. One of his main challenges is managing all of these responsibilities.

Addressing confidence and motivation issues in new computer science teachers: Gray often works with teachers to train them in robotics and he will be training 50 STEM teachers over the next three years to teach CS Principles. He is concerned that the STEM teachers who have no background in computer science will lack confidence and motivation in teaching the course.

Teacher certification: Gray noted that there are issues with CS professionals receiving certification to teach computer science at the high school level. Gray understands that CS professionals don't necessarily have the skills to teach in the classroom, but he feels that these professionals have to jump through many hoops to get the appropriate certification.

Lack of graduation requirements: Currently there are only 10 states that accept computer science as a graduation requirement. Davis said that it would be very challenging to have computer science as a required course in Alabama. As of May 2013, Gray is meeting with the Alabama State Department of Education on this issue.

They are hoping to classify CS as a permissible elective and then make CS a graduation requirement.

Misconceptions about computer science education: Wagner noted that a barrier for furthering computer science education is that teachers and administration have many misconceptions and misunderstandings about computer science. Wagner also spoke about the issue of stereotypes among students and that students think that computer science means sitting in front of a computer all day and means working with Microsoft Word or Excel.

ADVICE FROM UNIVERSITY OF ALABAMA

Start slow: Gray began summer computer science camps in 2004 with only five students. He said,

> *If I'd tried to grow that to what we have now, I probably would have failed. So each year, I pushed it a little bit more, and over ten years you get the word out eventually.*

Gray explained that there is a lot involved in dorm-based camps in particular, including planning social activities and hiring assistants.

Cultivate opportunities for sustainability: Gray said that so many programs end because there is not continued support in terms of funding and personnel.

Understand the context of a K-12 teacher: Gray spoke about the challenges that K-12 teachers face and how important it is to realize this from a higher education perspective.

Gray on teaching:

> *The real eye-opener I've had is how challenging it is to be a K-12 teacher. So I think a lot of my colleagues, research professors, have no idea what goes into being an everyday teacher. So I'll go out and occasionally run these all-day sessions where a school will ask me to give a talk to 6 classes, and by the end of the day I'm worn out, I can't speak anymore, I'm tired, I need to go home and lay down, and I teach right now, one course a semester and I complain that it's too hard. Teachers we work with are doing that six times a day.*

Understand the context of the university professor: Gray spoke about some common misconceptions people may have about university professors and the context in which they work. He said people misunderstand that professors only teach classes. He explained that he has many other responsibilities, including securing funding for his work. He also said that one challenge professors face is a lack of understanding of how to teach content. He said,

> *Just because [professors] know CS doesn't mean we know how to teach it at [the high school] level. It's kind of presumptuous of me to think that just because I have a PhD in CS, I am an expert on how to teach CS.*

Build trust with school districts: Crawford spoke about the importance of collaborating with school districts to build trust. She said,

> *In general I think you've got to build a level of trust with the districts. You've got to figure out who the decision makers are, you have to be available to talk to them, willing to listen to their concerns and understand where their pressures are.*

Keep it cheap: Wagner recommends looking for less expensive tools such as open source software or free resources such as Kahn Academy. Without a high price tag, efforts in computer science are more likely to be approved in schools.

Believe that students can achieve: Wagner believes that there is a tendency to simplify computer science to the point that it isn't interesting. She said,

> *I think that some people are afraid to use a more sophisticated programming environment such as Eclipse or Visual Studio with first time programmers when really it doesn't faze them; they're used to applications like Microsoft Word with lots of buttons and menus and they still know how to type a document, but those environments allow the students to expand and do more down the road, and the students see that and then they have the confidence that they can do it.*

School districts should use the expertise of university professors: Davis spoke about the importance of using universities as a resource to inform teachers about computer science. She said that Gray and his team have been essential in preparing teachers to effectively teach robotics in particular.

VISION FOR THE FUTURE

Raise the importance and value of computer science education: Wagner spoke about how essential it is for people to understand the importance of computer science education. She said that even today, university professors might lack understanding of the importance of computer science education at the high school level.

Gray on the value of CS education:

> *I'll ask the principal, "Why are you teaching this course X, after I just showed you where all the jobs are in the next eight years?" And they get a little bit upset with me, and I only use that approach when it seems like it's needed. I think students should take all the AP classes they can, but the most affluent high school here has an AP Latin class that has 120 students take, and that was the year we had seven students take the AP CSA. Last year, May 2012, CS had the most job offers of any major, and we've always been in the top five salaries. I show all this information, yet there's an imbalance in how we're preparing our students. The number one exam in my state is US history. We had over 5,200 take the AP exam in US history, and last year we had 97 students take AP CSA, which is the highest number, our highest ever. So I'm not at all saying don't teach US history of course, but we need to bring up where students are getting jobs. My grandfather competed with someone down the street, my grandmother, mother and father competed down the street with someone for a job, and our children are now competing with someone from across the world, and we need to escalate things.*

Increase numbers of AP CS Principles teachers: With Gray's NSF grant to train 50 AP CS Principles teachers, he is well poised to increase the numbers of teachers of this course in Alabama.

> *Integrate computer science into other courses in high school: Wagner envisions high school courses that integrate computer science, and that computer science is not just a stand-alone course. She hopes that teachers will realize the applicability of the discipline.*

Certify high school teachers in computer science: Wagner spoke about the importance of offering certificates for teachers in training to ensure that prospective teachers have a strong understanding of computer science and how to teach it in their classrooms.

GEORGIA: EXPANDING OVER TIME

The computer science effort in Georgia put down its roots about a decade ago and eventually led to: graduation credit for computer science in the state; four courses in computer science based on national standards; several computer science summer camps and weekend workshops for students; computer science teacher workshops; a computing teacher community; and a computer science teacher endorsement program. These accomplishments grew from a collaboration of committed educators at Georgia Tech, local high school teachers, and the state Department of Education. With support from the Toyota Foundation, the National Science Foundation and others, Georgia computer science leaders created momentum for computer science in Georgia and a foundation for future growth.

PEOPLE

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HISTORY

The Beginning: The computer science effort began in 2003 when the head of the Georgia Department of Education's Career, Technical and Agricultural education division reached out to an Assistant Dean at Georgia Tech. This state leader had signed on to the importance of computer science and placed a particular emphasis on growing AP computer science, in part because there was no other AP exam in the Career, Technical and Agricultural area. The AP CS exams were also changing from C++ to Java and the existing AP CS teachers needed help learning Java and object-oriented programming. One strategy for developing new computing teachers was to work with the business teachers in the state, who had previously been teaching computer applications. Computer applications was moving to middle school leaving computer application teachers available to learn something new.

Prior to the state's interest, Mark Guzdial at Georgia Tech had established a media computation course as an approach to computer science instruction that would appeal to liberal arts students and others and had established a track record of success with both men and women. This course was a foothold for the Georgia Tech and state collaboration. However, Media Computation was a Python course and the state wanted Java. Barbara Ericson was the best person for the job of creating the new Java Media Computation books and became an outreach person for the College of Computing. With state financial support the Georgia computer science effort began to grow.

Summer Camps: Georgia Tech started offering summer camps for high school students in 2004, and while these camps were popular, they lost money. Ericson decided to add camps for middle school students in 2006 and charge more for those camps to at least break-even. Ericson also thought that the camps were a good way to increase student interest in and exposure to computing. In 2009, Ericson added camps for elementary aged students (rising 4th and up) and the camps started to make a profit. The camps also became venues for trying out newly developed instructional materials. Eventually, they developed the camps into a financially viable model that allows them to be self-sustaining. Due to demand from parents who had sent their students to computing summer camps, Georgia Tech also added fee-based weekend workshops for elementary and middle school students during the school year.

Other Student Outreach: The summer camps have helped attract students to computing, but the majority of campers have been male. To attract more females to computing, Ericson started working with the Girl Scouts in 2005. Thousands of girl scouts have had an introduction to computing through Georgia Tech. Georgia Tech has also worked with Cool Girls, YWCA, and Black Girls Code.

Workshops for Teachers: Ericson runs 3-4 weeks of one-week workshops based on the courses in Georgia during the summer. The workshops began with financial support from the state and then with funding from the Toyota Foundation and eventually, around 2006, with funding from the National Science Foundation (Georgia Computes 2006-2011). The workshops target different levels of experience and knowledge, making it

clear that there are prerequisites for the various workshops. Ericson checks in with teachers to ensure that the workshop offerings are relevant for their needs and offers Professional Learning Units (PLUs), which are a required part of state recertification. Ericson also provides logistical support for teachers and follows up with informal e-mail communication and one-day workshops throughout the school year.

Competitions: To help prepare students for the AP CS exams, Georgia Tech has offered a practice multiple-choice exam since 2006. To encourage teachers to teach using Scratch and Alice, Georgia Tech has offered competitions in Scratch and Alice since 2010.

Faculty Workshops: In 2006, Georgia Tech received funding from the National Science Foundation for "Georgia Computes" a project that aimed to address the entire computer science pipeline including K-12 and higher education as well as increasing student interest and starting a lending library. The faculty workshops began through the Academic Advisory Committee on the Computing Disciplines – AACCD. At first, there appeared to be a lot of interest with about 25 participants at the first workshop. Then participation dropped. The project evaluator sought to find out why and according to Guzdial, they found that, "in any department only about 20% of the faculty actually care about undergraduate education." They realized that they had already reached them all and eventually stopped doing the workshops.

Lending Library: As part of Georgia Computes, Ericson created a lending library. The library enables teachers to borrow hardware (e.g. cell phones, robotics kits) that might otherwise be difficult to get or to justify purchasing. It also allows teaches to have enough equipment for an entire class to use, instead of just the few kids who come to an afterschool club. Many schools have purchased their own robotics kits after borrowing from the lending library and one county, Gwinnett, has also established a lending library.

Disciplinary Commons for Computing Educators (DCCE): While the work at Georgia Tech grew, others established complementary supports. Mark Guzdial, Lijun Ni of Georgia Tech and Allison Elliott Tew established the DCCE, a community focused on building collaboration among CS educators. Brianna Morrison, of Southern Poly participated in the first year and became a leader in subsequent years. This was a group of college and high school teachers who met monthly to collaborate and reflect on their teaching while creating a professional portfolio. Teachers shared resources, reviewed each other's written work and observed each other's teaching. When the Georga CSTA chapter started, much of the leadership came from DCCE participants.

Georgia CSTA Chapter: As Georgia Computes was growing, in 2008, Ria Galanos, one of the teachers that Ericson had been working with, helped to establish the Georgia chapter of the CSTA, along with other teachers from the Disciplinary Commons work of Lijun Ni and Briana Morrison. Galanos used the mailing list accumulated from Ericson's workshops to reach out to teachers interested in collaborating with one another. At the beginning, they met once a month to share ideas and teaching strategies.

State Policy for Computer Science: Having four computer science courses in Georgia makes it possible for a school to hire a teacher who really knows computer science because there are enough courses to support a full time teacher. After the 4 courses in computing were defined ("Computing in the Modern World," "Beginning Programming," "Intermediate Programming," "AP Computer Science A"), the state also developed a teacher endorsement in computer science, in an effort to allow computer science teachers the opportunity to have a credential that indicated they really knew computer science. Three universities/colleges in Georgia now offer the endorsement. However, very few teachers have attempted to obtain the endorsement since it is not required. There was also a push at the state level to make Advanced Placement computer science count toward high school graduation, in part due to the new requirement for all students to take 4 years of math and science by 2012. All students who graduated in 2012 and beyond can count Advanced Placement Computer Science A as a science for high school graduation and as a science or math for entry into Georgia's colleges and universities.

SUPPORTS AND STRATEGIES

A Core Group of Teachers: At the beginning, Ericson sought out teachers who others had identified as potential collaborators. She asked their opinions of the developing curriculum and whether they thought it would work. She was always communicative, responsive and attentive to her teacher colleagues. This was part of her larger strategy to work with a core group of teachers rather than a single group of schools or district. Now, those teachers are part of Georgia's computer science leadership.

> *I've worked with a core group of teachers over the years, and that's one of the cool things that's really happened in Georgia …that we've grown the community of teachers…so they are now taking on -- they run a lot of the workshops now, I don't have to run everything, which is great.*

Ericson works with these teachers to run summer camps, develop materials, and reach out to others. She advises,

> *Find the people who do lesson plans, who know how, and do them well, and hire those people to create lesson plans if you can. Also hire those people to go out and visit schools, because no one person…I get so many requests to come visit schools…having people that can go visit schools would be really useful thing to help teachers."*

State Allies: For the first couple of years, the computer science effort had strong advocates at in the Career and Technical Education Department at the Georgia Department of Education. As new leadership has come in, the CS education leaders have had to work to maintain the momentum of the computer science effort.

University Partnerships: From the beginning, Georgia Tech supported the computer science effort. The institution provided financial support at the beginning for summer camps and Ericson's salary and in general has been supportive of Ericson and Guzdial's efforts. Georgia Tech continues its support through the lending library and providing space and resources to the on-going teacher PD. Other institutions have been supportive as well. Wayne Summers from Columbus State was the Co-PI on Georgia Computes and was one of the first extenders of the summer camp program and now offers many summer camp opportunities. Also, Columbus State was the first place to offer the teacher computer science endorsement. Summers has been very supportive in trying to develop interest and send high school teachers to the professional development opportunities at Georgia Tech.

Organizational Partnerships: Partnerships with other organizations also played a key role. Ericson's work with the Girl Scouts helped expose more girls to computing and financial and materials support from Microsoft and others helped fill needed resource gaps. Further, once the CSTA Chapter was underway, they helped address needed content and pedagogical support.

All the workshops I go to are all about pedagogy, all of them. And it's awesome, because we need that -- there are ways to teach CS topics that are terrible, so that's important too but it's really hard to go to a workshop and hear all these great ideas when you don't have a place to put them in your mind because you don't know the material. So to get back to Barb, it never occurred to us to see if we could create a formal partnership. We had an informal partnership, and that's that Barb gave us keys to Georgia Tech and we didn't have to pay and she showed up at our meetings and she supported us and we supported her.

Policy Changes: Getting AP CS A to count as a science course has increased the number of schools who want to offer it. But there have been struggles. After having CS accepted as a science, the Georgia Board of Regents mailed descriptions of all science courses to science professors and asked them to judge the merits of the course based on whether the course would help students in their classes. As a result, AP CS A got dropped from the Board of Regents' list of courses that count towards science. Guzdial, Ericson and others went back to the Board of Regents who were willing to reconsider and count AP CS as either science or math. Ultimately, the State wouldn't accept the notion that a course might count toward either mathematics or science, so they stopped accepting it as a math, but still counts it as a science.

CHALLENGES

Finding Interested Faculty: It has been difficult to find university faculty who actually care about computing education and about becoming better teachers. Faculty care more about graduate education, promotion and tenure. Guzdial suggests that rather than try to change faculty, at the beginning at least, find those that are interested and work with them.

Finding Interested Teachers: Even where there is faculty interest and support, there is insufficient teacher interest. Both Columbus State and at Kennesaw State University offer the endorsement and to date have graduated only one person. As Guzdial said, *"We have way more capacity than we have teachers taking up that capacity."*

> *Why should the teachers want to get involved in the professional development, why should they care about learning how to do CS principles. I get that the goal of CS 10K is that when the new CS principles rolls out as an AP, we'll have more than ten thousand teachers available. There's the challenge: Until it rolls out, is there going to be an incentive for more than ten thousand teachers to learn about CS principles? Will teachers go to PD for a course that might one day be an AP?*

Perceptions of CS as Non-Academic: The computer science leaders in Georgia have been fighting a problem of perception on several fronts. At the state level, there is currently a focus on industry that is leading to "low level" IT skills rather than computer science. This has led to an effort to change the learning objectives for the first course to ones that are less rigorous.

Misperceptions also reside at the school level. Both school administrators and teachers fail to recognize CS as a complex discipline and expect that teachers can learn how to teach it with minimal training.

Galanos explains:

> *I think the biggest challenge right now is that no one is recognizing us as an academic discipline. It's absolutely okay that we're not in the core, I'm not suggesting that CS ever necessarily be in the core, but people really consider us still to be just a frou-frou elective, and not taking us seriously.*

Ericson explains:

> *So there's many issues, people didn't know what computer science is, they think computer literacy is CS, so if you know how to use a keyboard, so keyboarding classes, computer apps are all considered CS often in schools, and so getting them to understand the difference, getting them to understand that CS is more than you can learn in just a week, that's a big*

> *issue, that people don't have any idea what CS is, they have an idea that it's a low level programming job, they have no idea all the things you can do with CS, they have no idea how many different things there are to learn.*
>
> *So one big problem is that principals don't understand that you can't teach someone who knows nothing, enough to teach AP CS in one week. They'll expect us to, and send someone to a one week workshop where we say explicitly, do not take this workshop if you don't have any background in programming. People will say "I'm signed up to teach it, so I have to teach it.*

The misperceptions extend to the school counselors as well. Teachers complain that school counselors view the computing courses as "dumping grounds" for students with behavioral problems. Ericson explains, *"they think 'hey it's a computer, they'll get to play with a computer all day, that'll keep them busy, that'll keep them out of trouble.' So that's another issue that people have faced."* She feels that it is a *"never ending battle…to get people to see what it is, that it is important, that it is just as important as a science or a math if not more important."*

On-going Funding: At the beginning, Ericson had support from the state and the College of Computing to support her salary. Then, computer science was supported by a grant from the Toyota Foundation, and that was followed by funding from the National Science Foundation. The camps are now self-sustaining with computing summer camps going on around the state, reaching about 1000 youth in 2012. But, funding remains uncertain with shifts in the policy environment.

Providing Professional Development for a Range of Teachers: With the direction of the economy and associated reduction in teachers, the leaders have seen teachers who were enthusiastic about teaching CS and who attended PD lose their jobs. More experienced, but uninterested teachers have taken their place. This exacerbates the already difficult challenge of providing PD for teachers who are interested, but have a range of experience.

Galanos explains:

> *…it's really hard to do when you have veteran teachers and veteran CS teachers in a room with new CS teachers who are not even knowledgeable about CS; that's a ridiculous group of people to put in a room together, it doesn't make any sense.*

School Schedule and Departments: Even when schools open their doors to computer science, there are still serious challenges. Some are administrative. For example, the course sequence designed to lead up to AP resides in the "career and tech" department, not mathematics. Thus mathematics teachers have trouble teaching those classes because, as Galanos explained,

there was no principal that lets you teach in two different departments, that's just blasphemous. So they have to get business teachers to do it and they just became a mess.

It's been their experience that having computer science in the business departments has been a challenge because these teachers have become accustomed to teaching applications, and don't like to move out of their comfort areas to computer science. Other challenges have to do with finding instructional time in the schedule as computer science competes with other electives or with mathematics and science.

Yet another challenge comes from having teachers teach only single courses. With only one course and one section, teachers don't have the same kinds of opportunities to improve their instruction as teachers who repeat courses. Similarly, teachers are asked to teach multiple courses, and that increases the planning burden for those teachers. Crystal Furman, another teacher leader, explained she wants the district and administrators

> *to recognize that if you want to have a successful program, you can't overtax these teachers.*

Finally, Galanos feels that there is an emphasis on AP being the only CS class in the school. She feels it's important to have multiple levels of computer science for the range of students in the school. She recognizes that not all young students are ready for AP, but that doesn't mean that they aren't ready for computer science.

Need for Instructional Materials: Even with the accomplishments of getting computer science to count for credit and increasing visibility, there is an enormous need for quality materials.

Guzdial explains:

> *And one of the things that I've learned from Georgia Computes is how much things have to be packaged for teachers to be able to pick them up and use them. Most university faculty just don't get that. The way you pass a university course from one person to the other is you hand them your syllabus and your PowerPoint slides. Done. It's not the way it works at the K-12 level.*

ADVICE FROM GEORGIA

Engage Teachers and Build Teacher Community: Ericson explains that teachers would rather listen to one another than to someone else. Thus, allowing time for teachers to share and solve problems together helps to build the informal communities and builds leadership capacity for the overall effort. She emphasizes the importance of talking to teachers, visiting them, and learning what is happening in their classrooms. These teachers then become the experts on how to support computer science in their individual contexts.

Customize PD and Make It More Long Term: The Georgia leaders have made the most of their opportunities to provide professional development. They emphasize the importance of exposing teachers to more hours of professional development over a longer period of time; and of the merits of being able to work with teachers with similar skill and experience levels. The teachers they work with concur.

Galanos explains:

> *I think what's really important is that you address the needs of people in the room. If you're not equipped to handle people with different experience levels in CS, then you shouldn't have a workshop open to that many groups. If you're going to have an AP workshop and you are expecting that the people are already teaching AP CS, don't let anybody in who's not. It's important for us, if we're having workshops, to do as well as to listen, so that's how you really can gauge. Just like in the classroom -- that's the crazy thing about workshops is that teachers get workshops and don't treat the workshop like a classroom, it's the funniest thing ever.*

Another leading teacher, Christopher Michaud explained:

> *If I were in charge, if I were king, the way I would suggest to do PD for teachers would be to do it in situ, instead of pulling all teachers together all the time, sometimes taking five or six weeks and going to the school and teaching with the teacher, that also might be beneficial, because you can be gaining your experience in a four or five hour workshop but getting it to play out in a two or three week unit might be more difficult. So finding ways for teachers to maybe either visit or co-teach with each other or have a body of professionals at the college or even college students as part of their coursework to partner with a high school teacher and teach for a few weeks.*

Communicate to Parents: Ericson works to build demand for computer science by reaching out directly to parents. She sends letters from Georgia Tech and targets girls and minorities and encourages them to take AP CS or, if their school doesn't offer it, to ask for it.

> *…that's one of the things that's pushing schools to offer it because parents will push for it. Parents know this stuff is important; they want their kid learning high tech stuff. Schools tend to still have this attitude that you're preparing people for jobs right out of high school, especially in the career and technical, the business department, that's really where their focus is, that's what they think they're doing. And we can't quite get through their heads that that's not where most of the jobs are, and any job you'd get out of high school is a low level job that you'd be stuck in, would not really be a career.*

Collect Data and Customize: Guzdial is currently leading another NSF-supported project, the Expanding Computing Education Pathways (ECEP) project. In this work, they are using what they learned from the Georgia experience to help others develop computer science education. One of their emerging recommendations is to collect data on what is happening locally, what the local needs are, and local concerns and constraints. Then, with this information in mind, create a customized model for growing computer science. One size will not fit all.

Identify a Full-Time Leader: As with any improvement effort, it's important to have an individual, like Ericson, who is primarily focused on realizing the goals of the effort. While many dedicated individuals can contribute while still meeting other responsibilities, it is helpful to have a full-time champion who can facilitate coordination, communication and simply "keep things happening."

Engage Public Policy Stakeholders: As the story of computer science in Georgia reveals, it is very valuable to have good relationships with public policy makers; the effort has to reach all aspects of the system. In this case, having AP CS A count as a science credit increased the number of schools willing to offer it; moving it to be a required course in high school would obviously help even more. Engaging on the policy front can be an enormous challenge on its own, but it is essential for long term impact.

"Don't take no for an answer": Galanos articulated this well:

> *…when it comes to CS education, if I'm talking to someone who knows nothing about our field who's making crazy decisions, I don't give up. I keep at it until we make headway and sometimes you have to be... thoughtful about it and if your school district really responds to parents and will do anything parents ask, which of course is every school district's nightmare, then you have to get the parents on your side. If your school district responds to principals and principals can run their schools any way they want, then you have to get your principal on your side. You can't do it alone, and certainly the excitement in this country about CS right now is higher than it was a year ago, but it doesn't mean the superintendent's changed. But you just can't give up.*

VISION FOR THE FUTURE

The computer science advocates in Georgia are not short of vision. They range from more policy oriented goals, to those that excite the imagination with possibility.

More Diversity: Furman was eager to see more diversity in her classroom.

> *In my district, you put AP on the name of a class, and you've got kids just flocking to your room; because that's what they have been told is important, to take an advanced placement class; I'm also thinking that we will attract more minorities with them, so I'm hoping the diversity with our classes will be better in five years. My diversity is better today than it was five years ago; and it would be a dream to have 50:50 male female. I don't know if that will happen, but even if we got 25:75 that would be a huge improvement.*

More Statewide Efforts: Guzdial envisioned more statewide efforts:

> *We're going to see more states that are going to take computing education seriously, that are going to make it part of their high school graduation requirements, or at least something that counts towards high school graduation. They're going to create electives; they're going to create licensing. Within ten years CS Principles will exist. I'm going to be that within ten years, we could have CS 10K. I don't predict we're going to see it in five years. I don't think that we're going to get ten thousand new teachers just because the incentive system isn't there right now. I don't think that we're going to get all fifty states bought in. Man, it's hard to get all fifty states to buy into anything, and the models are so different.*

What Computer Science Might Become: Michaud imagined what computer science might become:

> *CS will no longer be on the screen, and we're just about finished with that era now. We call it robotics, but it's not really a great word for it. Smart devices, connected devices, the internet of things. I say to my own CS students now, that staring at the box on the desk is not the way that CS is going to be in five years. You will write programs and devise systems that people won't be looking at. They might be wearing them, they might be touching them, they might be listening to them, we might build whole buildings with them, but the screen and graphics is not the end. It's only the beginning…*

Concrete Goals: Galanos and Ericson focused on concrete goals:

…in five years -- we've gone from 300 people taking AP CS back when I first started, to over 1000 last year; I'd love to see it be 10,000 in four more; 100,000 would be great, that'd be more like the level of calculus. So I'd like to see us where calculus is. When I went to high school, not everybody took AP calculus in high school, now it's almost required if you think you're going into a STEM field, you'd better take AP calculus in high school. Well if you're going to a STEM field in the future, you'd better take CS. (Barb Ericson)

So I really would love if our country sort of... in five years really understood what CS is and what CS education looks like at the pre-university level as well as the university level and what people in CS jobs actually do. And I think if our country knew that, things would change. So I would like to see that for five years from now. I'd like to see it by the summer. (Ria Galanos)

PURDUE UNIVERSITY: PREPARING TEACHERS

The goal of the CS4EDU project at Purdue University is to create new pathways for undergraduate education majors to become computationally educated secondary teachers. This includes a joint effort between faculty in the Department of Computer Science and the College of Education to create a Computer Science Teaching Endorsement program. Dr. Aman Yadav and Dr. Tim Korb both contribute to the CS4EDU initiative and Dr. Chris Mayfield supported the program as a graduate student in 2010 and 2011. Learn more about others involved in this work. The main goal of this project is to create pathways for education students to become CS teachers.

PEOPLE

Dr. Aman Yadav

Associate Professor of Educational Psychology with a courtesy appointment in the Department of Computer Science at Purdue University

Dr. Tim Korb

Assistant Department Head in the Department of Computer Science at Purdue University

Dr. Chris Mayfield

Assistant Professor in the Department of Computer Science at James Madison University

PURDUE UNIVERSITY

HISTORY

The CS4EDU effort is an outgrowth of an earlier CPATH (Pathways to Revitalized Undergraduate Computing Education) project called Science Education in Computational Thinking that looked at developing a literate workforce in CS with the intent of engaging people who might have an interest in CS. This project is an attempt to improve the quality of CS teachers and to engage pre-service teachers who may not have considered becoming CS teachers. Korb said that there is also some growing interest from students who are CS majors who may want an alternative to working in the industry, and instead may want to work in school systems.

The Purdue University CS effort includes four pieces: computational thinking modules, a methods course, professional development workshops for in-service teachers, and education research. Learn more about these modules.

NSF CP (Pathways to Revitalized Undergraduate Computing Education) Grant: The team's goal with this grant is to develop pathways for undergraduate education majors to become computationally literate teachers, which will allow for more pathways for students to become computer science teachers. As part of this grant, the team developed two computational modules that are incorporated into core education courses: Learning and Motivation and Introduction to Education Technology.

Methods Course: Yadav and Korb also developed and taught a course called Methods of Teaching Computer Science. The team presented the course in person and online. Students who enter this course have strong CS content knowledge, but lack experience teaching CS to students. The goal of this course is to prepare pre-service teachers to teach high school CS courses. As of May 2013, three students completed this methods course and but one student completed the program and is currently teaching.

For more on this methods course, view this article.

Yadav speaks about the methods course:

> *So now the question becomes how do you teach this to somebody else? So the first part of the course we specifically talk about different types of approaches, for example, problem-based learning, peer programming, and all those things. And then, in the middle of the course, we focus on...so for example, we take loops and arrays. So how do you teach loops and arrays? So we take readings that specifically talk about loops and arrays, and the readings come from the Springer book on methods of teaching computer science, we read SIGCSE papers, and we discuss those in class. And then we have an accompanying lab with each section. So the students, after we talk about it in class, they go into the lab and do some activities that correspond with the discussion or the lecture portion*

of it. And then we also have high school computer science classroom observations. So we go to the classrooms and observe actual computer science teachers teaching.

Summer Professional Development Workshops for In-Service Teachers: A 2012 summer workshop for in-service teachers focused on the new AP course called AP CS Principles. About 40 high school teachers from Indiana, Ohio and Illinois participated in this three-day workshop. Participants heard from pilot teachers who discussed how they structured the course for their students. Workshop leaders also showed participants concrete activities and discussed pedagogical approaches.

Education Research: Yadav conducted CS education research to inform his modules for training pre-service teachers. He evaluated their computational thinking modules and look at how the module improved pre-service teachers' understanding. In 2013 and 2012, Yadav gave a presentation at SIGCSE and discussed research methodology in CS. Recently, he started to explore how freshmen undergraduate students learn recursion. Yadav hopes to apply these research findings to inform his pre-service teacher training courses.

Learn more about computer science education at Purdue.

SUPPORTS AND STRATEGIES

Distance Learning: In-service teachers shared with Yadav that they would find a CS teaching methods course to be very useful, but they find it too challenging to visit the Purdue campus on a weekly basis. To address this issue, Yadav and his team are planning to offer a methods course online to in-service teachers.

Recruit from Different Sources: The team recruits math and science track pre-service teachers early on in their training to become computer science teachers. The team's strategy to recruit pre-service teachers includes exposing them to the computational modules that are part of core teacher training. The team also recruits in-service teachers through listserves and the local Computer Science Teachers Association (CSTA) chapter. Yadav easily recruits teachers for his workshops through his Indiana chapter of CSTA.

Korb speaks about recruiting in-service teachers as a good potential strategy to recruit more teachers to teach CS:

> *One of the areas we're now looking at is at in-service teachers: high school teachers who've already made the commitment to work in a high school setting. They may not have strong CS backgrounds, they may not have a lot of training in that area, but they may have an interest in it, and an aptitude for it, so we're now looking at PD opportunities for them. How can we give them the right tools they need in order to teach CS and get high school students engaged in CS education, so that when the students get to the university they're interested and comfortable in the area.*

Focus on Districts that Want Your Help: Yadav:

I feel like I can't go and tell a school district to have a computer science program, you know? I think if their local conditions require a computer science course or program, that's when I think we can step in and help them, rather than me going and telling a bunch of schools.

Faculty Fellowship: For the 2012-2013 school year, Yadav received a Purdue fellowship to study a second discipline. This fellowship allows Yadav complete release from teaching responsibilities and the ability to study CS. He will take courses in CS to boost his CS content knowledge.

Multiple Entry Points into CS for pre-service teachers: Korb said,

> *We still need to have multiple entry points for our program so that students with no background in CS are not overwhelmed, overloaded or intimidated by the presence of students who have a computing background.*

University Support: Purdue provides essential support that helps to successfully run their K-12 outreach programs with the help of an outreach coordinator. He explained that Purdue is a land grant with a mission to reach out and engage the community. He said,

> *It's very much politically and institutionally a part of our culture to engage the community and engage the state.*

Corporate Partner Support: Korb spoke about the importance of receiving financial support from Google, State Farm and others that helped the Purdue CS initiatives with startup or general support. Companies also provided equipment, software and staff for summer camps. He said that corporations realize that engaging CS students and encouraging the study of CS is very important for the success of our country and for the success of the companies themselves.

Use your resources: Mayfield spoke about the value of using existing resources such as SIGCSE, NCWIT, Mark Guzdial's blog, and Google's CS4HS program.

CHALLENGES

Recruiting pre-service teachers to CS: Yadav said that typical pre-service teachers are focused on becoming math or science teachers, not computer science teachers.

Recruiting CS professionals to teach: Yadav said it is challenging to recruit CS professionals to education because it is hard for CS teachers to find jobs and CS professionals usually find higher paying jobs than teaching.

Korb explains this challenge:

> *We still have a challenge encouraging students to consider high school CS teaching as a career option. It's not a particularly attractive option for many students because the job market for computer science graduates is so strong--there are a large number of companies recruiting students all the time, they have signing bonuses and large offers and very attractive working conditions.*

Offering in-service teachers University courses: Yadav described that there are some logistical barriers to offering Purdue courses to in-service teachers who are not part of a degree program on campus.

Low student enrollment: Yadav spoke about how low enrollment in CS courses is a challenge CS teachers face. He said that low enrollment is an issue because there is a misconception that jobs in CS don't exist in the United States and that jobs are outsourced to other countries.

Yadav on low enrollment:

> *But I think they face challenges in terms of lower enrollment, and now, schools, as a result of budget cuts, schools want a minimum number of students for a class to happen. If you only have five or six students where four or five years ago, it'd be okay to run that course, it's not so anymore. Say the teacher retires, and she's had a course with six, seven students. Now will the school continue, with six, seven students, you know? Or hire a new teacher to replace that teacher. That's a challenge for school districts.*

Engaging active CS teachers: Korb spoke about the issue of making sure they are reaching all CS teachers in Indiana. He said,

> *It's hard to find them because they're not always identified as CS teachers; oftentimes they're a math teacher who teaches a CS course, oftentimes in Indiana a lot of CS is done as an outgrowth of the business department so many are in the business department.*

Crowded high school curriculum: Korb spoke about the issue that students don't have the time to take CS courses, so he thinks about how to integrate CS with other disciplines.

Korb on student schedules:

> *But the fact is that the high school curriculum is crowded. The students are already taking a lot of math and a lot of other required courses. In addition, the best students are well rounded, taking a lot of extra curricular courses. There's just not a lot of room for yet another series of courses in the program. So, we're slowly facing the issue of what gets displaced in order to teach CS or what can CS be integrated with? We thought integrating CS with mathematics was a natural option, and we continue to pursue that. There's been some interest in combining CS with physics, because there's been some curriculum materials developed that use programming techniques in the physics curriculum. We may continue to grow interest in CS in the high schools by integrating it with other disciplines and activities. One of our contacts is with a new tech high school in Indianapolis, where their approach to teaching includes problem based learning and integrating multiple disciplines. We're looking at working with them on the possibility of combining one of their courses that would include a CS component along with math or physics or some other discipline that could be used to apply those techniques to some problem of interest.*

Misconceptions about CS: Korb spoke about how the challenge of recruiting students and teachers into the field of CS relates to the fact that many people have misconceptions about the field. He said,

> *It's a great field to be in, it's an exciting, great way to have an impact on society and people don't realize that. They think of it as a very lonely profession, but in fact it's very social and dynamic, so we're hoping that there's something that will help us. There was this recent video that went viral for a while that had a number of celebrities talking about the excitement of CS. We need some more things like that. That focused on computer programming which is a very engaging part of computing but not all of computing, so we're hopeful that those kinds of things will happen.*

Mayfield on misconceptions of CS:

> *I think it's because not a lot of people understand it. I think people have a general understanding of what engineering is, it's hands on, it's building things, it's working in a lab, and this is all stereotypical too to say these sorts of things, and I think people understand science is like wear the lab coats and pour the tests tubes and do the dissecting of things, or you do experiments in physics, and everyone's had math since they were in grade*

school, and technology, that's using computers to do things, but CS, if you just throw that term out there, people aren't quite sure what to visualize, how to relate to that, and they're not sure, is this science, is it technology, is it math, is it something that's like technical education like mechanics and shop or is it academic like mathematics, and even the community itself struggles at times to define where the field sits. Is it in engineering, or science or all of the above? So because it doesn't have a very clear definition in the masses' mind, that's why it's sort of left out, people just don't think of it, and there's no letter in the acronym of STEM that clearly is CS.

Interdisciplinary scholarship is usually not a priority of university professors: Mayfield said that the interdisciplinary scholarship in CS happening at Purdue is not recognized as core CS research and is lower priority at research universities like Purdue. He said that this sort of work is not always recognized as highly as writing for publications or producing PhD students.

ADVICE FROM PURDUE UNIVERSITY

Stakeholders in Indiana had many insights about how their efforts have been successful.

Train teachers not just the content but also how to teach it: Yadav said that it is important to understand the kinds of issues and challenges teachers face in the classroom and how this relates to teaching CS concepts and content. He explained that great professors or researchers are not necessarily good teachers; they understand the content but may not know how to deliver the content. Yadav recommends that teacher training not just focus on learning content but also pedagogical content knowledge, or how to teach.

Make true connections with potential collaborators: Building mutually-beneficial relationships takes time. Yadav on reaching out:

> I'm a big believer in just picking up the phone and making the call. You know, and just to see if there are common threads where people can explore. For example, I think of my own experience when my colleagues in computer science and I first talked about doing this project together, I had no idea what computational thinking was and I have a CS background. I've programmed before, so I understand these concepts. But, on a surface level, if you just say this is the title of the project, are you interested in working with us? without that in-depth understanding about what it is about, it'd be hard for me to say sure. So I think maybe just walking next door, or picking up the phone and make a phone call, is that what's led to our collaboration.

Understand the high school teacher context: Korb spoke about the importance of understanding the school environment, the demands on teachers, as well as understanding their needs.

Korb explains:

> *One of the things that I learned most was it's a very different environment [in high school] than what you have in a university. Teachers are very time constrained: most CS college professors at R1 universities teach one or two courses at a time; high school teachers are teaching five or six. It's just a very different environment and I think it took us a while to understand and appreciate that they don't have time to go figure something out and experiment with new ideas on their own. The other difficulty they have is many of their students are not really interested in their programs, and so motivation is a big factor for them. Our students tend to be more motivated, they've already made the choice that this is what they want to do so they're here. We take advantage of that*

motivation and so don't worry about motivating them as much. Whereas high schools you have to spend a lot of time finding ways to engage students, to entertain them, to get them interested in this area. I think recognizing that is an important point.

Collaborate with teachers: Mayfield talked about the importance of collaborating with teachers and across departments at the higher education level. He said that teachers can provide input on what support they need and how to improve PD experiences. He said,

I think it's important that teachers ultimately feel like a full partner in the process that they're not just the students coming in to get taught. I honestly see the teachers we bring in as peers and people that can help me -- I expect to learn from them as well.

VISION FOR THE FUTURE

Pair CS faculty and education faculty together in higher education to train teachers: Yadav found that this collaboration proves to be effective in training teachers to learn both CS content knowledge as well as how to teach CS.

Make research-based decisions: Yadav would like to see more funding for an empirical research base to support decisions and to determine what is effective in CS education.

More CS teachers and more students: Yadav hopes that the CS10K effort will come to fruition and we will have 10,000 CS teachers in our country. He hopes that in five years, more students will be interested in CS and that we will better understand how to measure teacher and student knowledge in computer science.

Share research findings: Yadav is hopeful that professionals and researchers within the field of CS education will share their ideas instead of guarding them. He said,

> *I feel like we're all in this together, so what's better for me is also better for the community, and what's better for the community is also better for me.*

Greater understanding of CS: Korb would like more people to realize the importance of CS, including what programming is, and how computers work. He said it is very important for students to deeply, not superficially, understand our technologies that we rely on.

CROSS-SITE THEMES

"Stories from the Field" shares the experiences of people who have acted locally to advance computer science education nationally. The sites represent a range of locations, institutions, and strategies that demonstrate some of the different pathways others can take to further computer science education in their own communities. University faculty, curriculum developers, district administrators, teachers and others share their perspectives, their successful strategies, their biggest challenges and offer insights and recommendations for others.

In April and May 2013, researchers interviewed 3-7 individuals per site. The interviews began with a single, primary leader who then recommended others to participate. Researchers also reviewed effort artifacts and on-line resources.

▼Misconceptions about CS education abound

Misperceptions about CS may be the biggest barrier to growing computer science education. Students perceive computer science is lonely and dull; parents aren't aware of employment opportunities; teachers don't view it as a core academic subject; and administrators and policy makers perceive it as low level IT. To paraphrase Chris Mayfield from James Madison University, it doesn't have a very clear definition in the masses' mind so it is left out. People just don't think of it. There's no letter in the acronym, STEM, that associates with CS. Efforts to communicate what CS actually is, how it is applied in a variety of contexts, and what the nature of computer science work is needs to improve and continue.

▼CS education growth depends on more quality materials and resources

There are many valuable, growing resources. Mark Guzdial's blog , code.org, national organizations such as CSTA (the Computer Science Teachers Association), NCWIT (National Center for Women and Information Technology), SIGCSE (ACM's Special Interest Group on Computer Science Education), and the National Science Foundation (NSF) and Google's CS4HS are all making contributions to the field.

However, as demand for computer science expands, the success of that growth will depend on access to more thoughtfully developed, principled, practical, and applicable instructional materials and resources. Teachers should not be burdened with the task of creating their course materials from the ground up, particularly those who are new to the discipline (as many new CS teachers are likely to be). The stories describe a start, with ECS, media computation and AP, but there remains significant need and opportunity for growth.

▼Recruitment & preparation requires communication, flexibility, & support

CS teacher recruitment faces several challenges. First, potential CS teachers don't see an enormous demand. Second, individuals with CS preparation have opportunities in more visible and higher paying fields. Third, current computer science professionals don't have many pathways toward the preparation and certification they would need to teach. Teacher recruitment and preparation programs need multiple, flexible entry points to reach the broadest audiences.

Further, once in the field, CS teachers (as all teachers) need and deserve quality, engaging and enduring professional development. With many potential CS teachers coming from other disciplines with a range of teaching experience, CS professional development efforts can capitalize on the growing knowledge base of quality professional development in other disciplines to meet CS teachers' wide ranging, continuous needs.

▼There are unintended consequences of graduation policies, schedules, & requirements

As of May 2013, ten states (Georgia, Missouri, New York, North Carolina, Oklahoma, Oregon, Rhode Island, Texas, Virginia and Washington) allow CS courses to count toward either a math or science graduation requirement. In other states, computer science competes for space in a student's elective schedule and even in the states that do count it, students' misconceptions can stand in the way of choosing CS.

Other challenges come from where CS lives within a school. As the Teacher Capacity Study demonstrates, CS courses reside in a wide range of departments from CS to mathematics to CTE, business, and science. Decisions about where CS courses reside can impact the availability of teachers, course enrollment, and schedule availability.

Finally, while there are some teachers who have the opportunity to teach multiple sections of a CS course and more than one CS course, that is not the norm. More often, teachers teach primarily in another field, or they teach CS as part of their teaching portfolios that might include other business or CTE courses. Creating opportunities for teachers to garner more instructional experience and disciplinary knowledge will require continued effort to shift current policies and practices.

▼Partnerships can take different forms and all of them can be helpful

Partnerships were key elements of sustaining and expanding the CS education efforts in all four sites. Each partnership varied by the needs of all parties involved, and the evolution of the CS effort. Partners included universities, corporations, policy makers,

schools and school districts and computer science professional and advocacy organizations and support took many forms including financial support, motivation, facilities, human resources and materials.

It appears that the most productive partnerships are those that grow through compatible if not common goals, communication, and on-going demonstration of how working together benefits all parties involved. Partnerships will be necessary for CS education growth; decision about how to develop, focus and maintain those partnerships will need to target the customized needs of each partner and community. New efforts can take a lesson from the Chicago leaders – they made a commitment to their common goal and to one another to persist and today, they have much to show for their efforts.

▼CS leaders must collaborate with and build the local teacher community

Because they reside in a variety of departments and often teach in isolation, CS teachers can sometimes be hard to find. Thus, leaders can't always identify them and it's also difficult to find one another. In some cases, developing a local teacher community and network can be a first step to growing and developing computer science education; in others, it follows other strategic steps. Regardless of the particular strategy, working to develop and support a CS teacher professional community can be an important key to developing CS teaching knowledge and skills and to developing future leadership.

▼Computer science education isn't a priority for many faculty

Higher education institutions' conditions and contexts are not always conducive to working with K-12 education. Some faculty simply aren't interested; others feel conflicted about their personal beliefs and interests and the constraints and demands they have as university faculty. Mark Guzdial at Georgia Tech offers some practical advice – rather than try to change faculty, find those that are interested and start by working with them.

▼Leaders need to consider sustainability from the outset

Any educational improvement effort that has the benefit of external funding also faces the challenge of how to navigate the inevitable reduction or removal of that funding. There are no simple solutions to this dilemma, but general principles such as building broad, shared vision; developing partnerships; collecting evidence on and communicating successes; and developing mechanisms for continuous improvement can help create a foundation for a more enduring effort.

Under the direction of the Association for Computing Machinery (ACM), in partnership with the Computer Science Teachers Association, Google, Microsoft, the National Center for Woman and Information Technology, and the National Science Foundation.

Funding provided by Google