Recommendations for Designing CS Resource Sharing Sites for All Teachers

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ABSTRACT

Many organizations have developed websites to support high school computer science (CS) teachers by providing them with collections of teaching resources. Yet rarely do these sites take into account the unique challenges of new CS teachers who often have not had formal training in CS. In response to a documented lack of teachers' engagement on these sites, we interviewed 17 CS teachers to learn more about the ways in which these sites are and are not meeting teachers' needs for curriculum resources. We discuss our findings about how teachers use, adapt, and share resources and then provide several suggestions for designing resource sharing sites that support teachers who have varying levels of experience teaching CS.

Categories and Subject Descriptors

K.3.2 [**Computers and Education**]: Computer and Information Science Education—*computer science education*

Keywords

Resource repositories, Curriculum sharing, Online resources

1. INTRODUCTION

There is a stark imbalance in which students and communities have access to computing education [37, 9, 17]. In response, the US has launched the CS4All initiative [49] to provide all students in the US access to computer science (CS) instruction. With a similar goal, the National Science Foundation, Code.org [14], and a variety of organizations across the world have launched initiatives to train high school (HS) teachers to teach computer science (CS) [22, 14, 20]. Training these teachers is of vital importance to addressing inequities in access to CS instruction.

To support these initiatives, many online platforms connect HS CS teachers by encouraging teachers to share resources, e.g., lesson plans, activities, assignments, and tests.

Sharing resources with other CS teachers is important because high schools that offer CS often have only a single CS teacher [12]. Unlike teachers in other subjects, CS teachers often do not have opportunities to have face-to-face interactions with others who teach the same subject and can feel isolated [42]. While in-person professional development (PD) has been shown to be effective in supporting CS teachers [33, 43], PD workshops alone may not provide teachers with everything they need. Online resources are an important mechanism for providing teachers with additional support [7, 26].

The following 16 sites provide repositories of free educational resources of interest to HS CS teachers [1]:

- Alice Community [1],
- Blueroom [5],
- Canterbury QuestionBank [10],
- Code.org Forum [15]
- College Board AP CS Teacher Community [16],
- Computational Science Education Reference Desk [18],
- Computer Science Open Educational Resources [19],
- Computing At School Community [20],
- CS10K Community [22],
- CSTA Source Online K-12 Repository [23],
- Ensemble Computing Portal [25],
- Greenroom [28],
- MIT App Inventor Resources [38],
- NCWIT Engage CS Edu [41],
- Nifty Assignments [44], and
- ScratchEd [47].

Despite the presence of these and similar sites, it has been noted that many resource sharing sites that serve CS teachers are underutilized [24, 26, 30, 39]. While prior research has developed explanations for the underutilization of existing sites for CS teachers [24, 26, 39], we focus on strategies for increasing participation on these sites in order to better serve teachers and ultimately students. We reviewed literature regarding online CS teacher sites and interviewed 17 teachers to address the following research questions:

- What are the barriers to CS teachers' engagement with resource sharing sites?
- Which CS teacher needs are met and unmet with resource sharing sites?

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[1] Many of the repositories on this list include discussion and other community features that support informal forms of resource sharing. We have not listed the numerous online communities and social media outlets that are designed for HS CS teachers to communicate but do not include a repository of resources.

During our interviews we learned that CS teachers want cohesive curricula to use and adapt (Sections 4.1, 4.2) and that they have concerns about sharing their resources and participating in online discussions (Section 4.3). Meeting experienced teachers' needs for resources and helping them overcome concerns about judgment is challenging. Addressing the needs and concerns of new teachers is an even greater challenge.

It has been documented that there are large gaps in knowledge and behavior among novice and experienced teachers in many subject areas [52, 53]. Understanding how these gaps affect the ways in which CS teachers locate, adapt, and share teaching resources is important for understanding how to support CS teachers with varying levels of experience. In this paper we discuss our interview results and present a synthesis of research related more broadly to online resource sharing, communities, and discussion to provide insights into the design of online resources to support HS CS teachers with different levels of experience[2].

2. PREVIOUS RESEARCH

2.1 New CS Teachers

Prior research has reported that new teachers across domains spend a significant amount of time searching for resources [29]. At first they follow these curriculum materials closely, and, as they gain experience, they begin adjusting these materials to meet their specific students' needs [29]. Although many CS teachers may have experience teaching other subjects [12, 42], in cases where teachers have not had formal CS training, it can be difficult to know how to adapt CS resources to meet their students' needs [8, 31]. Responding to teachers' interest in using online resources, we discuss several design strategies for resource sharing sites to help new CS teachers find the resources they need (Section 4.1).

2.2 Resource Adaptation

Research has documented that CS teachers have difficulty finding high-quality teaching resources [24, 39]. Teachers must adapt their materials for many reasons, including the constraints of their class schedules and the abilities of their students [3]. It has been reported that the resources developed by content experts are not ready for classroom use without a teacher's modifications [45, 50]. Adapting resources from an online repository is common practice for teachers in many subjects [6], including CS [26]. Adapting teaching resources for use in the classroom requires teachers to have a significant amount of background information about these materials [50]. However, many online repositories of materials for K-12 teachers provide fragmented collections of resources rather than cohesive units [11]. These fragmented collections can be particularly discouraging for new teachers so we consider additional strategies sites can use to help new teachers locate materials (Section 4.2).

2.3 Resource Sharing

Motivating contributions to online knowledge repositories and online communities has been identified as a challenging

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[2]We will use the phrase, "new CS teachers," to refer to teachers who are both new to teaching CS and do not have deep CS content knowledge, which is independent of whether or not these teachers have experience teaching other subjects.

Table 1: Participant Backgrounds

ID	HS Type	Only CS Teacher	Years As CS Teacher
T1	Rural	Yes	1-3
T2	Rural	Yes	7+
T3	Suburban	No	1-3
T4	Suburban	Yes	1-3
T5	Suburban	No	1-3
T6	Suburban	Yes	4-6
T7	Suburban	No	7+
T8	Suburban	Yes	7+
T9	Suburban	Yes	7+
T10	Suburban	Yes	7+
T11	Suburban	Yes	7+
T12	Suburban*	No	7+
T13	Suburban*	Yes	7+
T14	Urban	Yes	1-3
T15	Urban	Yes	1-3
T16	Urban	Yes	7+
T17	Urban	Yes	7+

Entries with (*) are private schools. All others are public.

problem [2, 32, 34, 51]. Fear of criticism has been cited as one of the major concerns people have when deciding whether or not to contribute to an online community [2]. Previous research discusses the difficulties of convincing CS teachers to contribute to online resource sites [24, 26, 35, 46]. CS teachers are often unmotivated to share because they receive too little recognition for their contributions [24, 26]. In this paper we document further concerns CS teachers have about judgment from their peers and propose strategies for encouraging sharing and participation within discussion forums on resource sharing sites (Section 4.3).

3. METHODS

To find the names of HS CS teachers, we used the membership directory from the College Board AP Computer Science Teacher Community [16]. On teachers' school websites we found contact information for 149 of these teachers within a geographic region and emailed them to request video interviews. We also posted a request on a CS Teachers Association email list within the same region. Each participant was offered $50 for participating in an interview.

During semi-structured interviews [21] that lasted approximately one hour (ranging from 35 to 72 minutes), 17 teachers were asked about their use of online teaching resources. A summary of participant backgrounds is provided in Table 1. All participants consented to have their interviews recorded.

We entered the interview transcripts into Saturate App, which is a qualitative data analysis application [48]. We used this program to tag quotations of interest in a process of open coding [21]. After 12 interviews we did not hear substantially new ideas, i.e., we reached saturation in our sample [21], but we interviewed all 17 teachers who replied to our interview request. We used these tags to identify a set of primary insights based upon the themes and variations among interview responses. The three main themes that emerged centered around new CS teachers, resource adaptation, and resource sharing.

Although the teachers we interviewed had similar levels of experience to those reported in the Building an Operating System for Computer Science (OS4CS) Teacher Capacity Study [12], we suspect that many of the teachers we interviewed have more experience than the average CS teacher. Additionally, teachers who have experience with online resource sharing platforms might have been more likely to elect to participate in our interviews. We recognize these biases in our sample, but based upon the consistency within our sample and with previous research we believe our participants' experiences with CS teaching resources are representative of many other teachers' experiences.

4. FINDINGS

4.1 New CS Teachers

Many of our participants had several years of experience teaching CS (Table 1), but they talked about their perceptions of their needs as a teacher both past and present. One participant, who is an experienced teacher, reflected on his improvement in teaching over time:

> I actually feel sorry for the students I was teaching, like, seven or eight years ago. . . The classes were not nearly as good.
>
> (Q4.1.a, T10)

Many of our participants acknowledged the importance of having adequate support for new CS teachers:

> I think a lot of them are really deer in the headlights of, 'Oh my goodness, my principal said I've got to teach computer science, and how do I possibly do that and do that well?' I think any support that they can get would be greatly appreciated . . . It's kind of hard to ask, 'How do I best teach a for-loop?' when you may not completely understand what a for-loop does yourself.
>
> (Q4.1.b, T13)

Even new teachers with some background in CS seek curriculum resources. One participant, who majored in math in college and took only a single college-level CS class, discussed the importance of accessing resources when he first started teaching CS:

> For me it was very daunting to be, like, I taught math for four years, and I'm feeling okay about this. Now I have to teach a totally different subject. . . so it was nice to have a lot of resources that first year.
>
> (Q4.1.c, T4)

Many of our participants described the value of accessing a full curriculum as "a starting point":

> Especially when you're starting a new class, a new language or whatever, having a curriculum available certainly makes the job a lot easier. . . You're not going to, like, copy somebody else's curriculum, but having a starting point is pretty valuable. And then maybe you would change it, or add to it, rather than having to start from scratch.
>
> (Q4.1.d, T12)

Having other teachers' resources as "a starting point" can help new teachers plan their full courses and more experienced teachers incorporate new lessons and activities into their existing courses.

4.2 Resource Adaptation

Experienced teachers appeared motivated to improve their curriculum through providing novel assignments and providing differentiated instruction. One of the participants said, "I constantly am looking to see what's out there. I Google and search and look around, and there's an unbelievable amount of good stuff out there" (Q4.2.a, T10). Another participant discussed the goal of accessing resources for inspiration and did not expect to use these materials without modification:

> I look at something [and say], 'Oh, that's a cool idea. I wonder how I can modify that for my students and change it a little bit.' To me that's very valuable. I'm not saying that I need to be able to take someone's lab and just copy and paste it. I don't really want to do that, but it's nice to have a starting point and somewhere to jump off 'cause the daunting part is building from scratch.
>
> (Q4.2.b, T4)

Participants reported that having a "starting point" from which to adapt resources can save time and provide the opportunity to adjust materials to suit their students' needs.

Participants reported that a major barrier to finding good resources is the time it takes to determine whether a resource is consistent with their curriculum. When examining resources, one participant said that he often has to make many adjustments to the materials he finds. He said, "It's not like it's out there that easy to find. You know, not in the form that I want it (Q4.2.c, T13)." Participants said that assessing and modifying pre-existing resources can be challenging and time consuming. Another participant discussed concerns about determining if a particular resource fits into the sequence of topics covered in his class:

> So I see that that's a good idea, but I have to tailor it for what the students are learning at the moment or what they have learned so far. . . It's really hard to find a lesson that will fit your class at the moment.
>
> (Q4.2.d, T8)

Another teacher said that having the syllabus to see the outline of topics is essential for evaluating the adaptability of another teacher's resources:

> Let me take a look at the syllabus and see where they're going with it and is this something that is going to be a real effective set of resources for me.
>
> (Q4.2.e, T11)

Our participants indicated that adaptation is time consuming because it is difficult to find resources that match their curriculum standards, the needs of their students, and the topic sequence within their course.

4.3 Resource Sharing

Online resource sharing sites rely upon teachers to upload and share their materials. Many participants said that they would like to help others by sharing their resources but that they had concerns about sharing. One teacher said that although most people are friendly on the sites, condescending comments do sometimes appear:

Somebody who is new and is starting out, maybe they'll ask, like, stupid questions, right, because they don't know. They're just figuring it out. Sometimes you'd see some kind of snobby sort of responses, but it wasn't so bad.

<div align="right">(Q4.3.a, T12)</div>

While unsupportive comments may not be common, many teachers remain concerned that resources they share will receive a judgmental response. One teacher indicated his concern about sharing his resources because of his lack of background in CS:

A lot of us teaching high school, if we don't have a computer science degree, there might be a reluctance that maybe this isn't really quality stuff, and maybe I don't want it out there for my colleagues to nitpick.

<div align="right">(Q4.3.b, T13)</div>

Teachers without formal training in CS appeared particularly concerned about revealing their lack of CS content knowledge through sharing resources.

5. SITE DESIGN SUGGESTIONS

Based upon our interview data, we propose a number of strategies for organizing the landing page, main content, and discussion forums on sites for HS CS teachers with varying levels of experience.

5.1 Landing Page

The landing page, which welcomes site visitors, should recognize users will seek different content and will be coming from various backgrounds. We recommend that the landing page of CS teacher sites allow site visitors to identify their background and their interests in visiting the site. Sites should ask two questions: "What is your current role?" and "What course and grade level are you interested in?" Asking these questions will allow sites to serve two important roles: providing teachers with more relevant content and helping people feel welcome on the site. As T13 indicated (Q4.1.b), many new teachers are uncertain of where to turn for help and can feel lost. By providing an opportunity for teachers to give information about their backgrounds, the sites can accommodate their differing needs and signal that the site can be of use to them regardless of their prior experiences.

5.2 Main Content

The main content of the site comprises the resources teachers seek. A number of sites have been developed to provide additional support, but the common format for many of these sites is to have individual units of curriculum that are not connected to other materials from the same course offering. This structure is likely inaccessible to new CS teachers, who, by definition, have not taught the course before and often lack formal training in CS [12].

We suggest that sites display all resources in the context of the author's full course. For new CS teachers with little or no background in CS, resources provided within the context of other course materials can provide the necessary support to become more effective teachers. Several participants, including T12 (Q4.1.d) and T4 (Q4.2.b), discussed the value in seeing other people's resources and adapting these materials. T8 (Q4.2.d) discussed the challenge of determining if a resource from another author fits within the structure

of his class, and T11 discussed using the syllabus to determine whether another teacher's set of resources matches the structure of his course (Q4.2.e). This essential contextual information for resources is missing from how current sites for CS teachers organize resources.

We argue that organizing resources within the context of a full course can help teachers understand where the resources fit within the structure of the course. New teachers can benefit greatly from being able to have a full set of resources to use the first time they teach a course. In addition, for more experienced teachers the burden of adapting resources can be minimized if they can find other teachers' complete course materials that meet the same standards, serve a similar population of students, and have an ordering of topics that is consistent with their course. Organizing content in the context of complete courses would make resources more accessible to a wider population of CS teachers.

5.3 Discussion Forum

Many of the existing sites offer discussion forums for site members [1, 5, 16, 20, 15, 22, 28, 47]. Several of the teachers we interviewed discussed concerns about being judged by their peers within these forums. We believe these concerns can be alleviated by allowing for both anonymous and non-anonymous posts within discussion forums.

Although concerns about judgment from their peers have not been documented in the previous literature on resource sharing among CS teachers, our interview results indicated that fears of showing gaps in their CS knowledge may discourage many teachers from sharing their course materials with other teachers. We expect that teachers in many subjects would share these concerns, but we suspect that these concerns are exacerbated among CS teachers because often even experienced CS teachers do not have a background in CS [12]. Although many online help-seeking tools, such as Piazza, support both anonymous and non-anonymous posting, the only site that our participants discussed that enabled this capability was the Beauty and Joy of Computing Piazza forum. T13 discussed concerns about not having a background in computer science and facing judgment from his colleagues about the content of his resources (Q4.3.b). These concerns about judgment could be reduced by allowing teachers to post content anonymously.

6. DISCUSSION

Our review of prior literature and our interviews indicate that the difficulties that experienced CS teachers face finding and adapting resources are even more burdensome for new teachers without background experience and content knowledge in CS. Finding appropriate materials to adapt can be challenging because individuals with and without domain knowledge search for materials differently [54, 4]. Search often requires users to know relevant vocabulary to find what they are looking for [54], which is unrealistic for many new CS teachers [12, 42]. Current sites largely ignore the differences between new and experienced teachers, which makes it difficult for new teachers to locate teaching resources. Adding metadata to resources related to their "pedagogical function, ownership, version and access provisions" is critical for enabling teachers to search for materials effectively [13].

Many existing sites provide spaces for CS teachers to participate in online discussions and help forums. While our participants acknowledged the importance of finding high

quality teaching resources, they indicated concerns about being judged by their peers within these online spaces. These concerns would be particularly prohibitive for new teachers without content knowledge and formal training in CS. The literature on motivating participation in online communities more broadly has made a number of recommendations for motivating participation. These include promoting a user's unique value to the community [2, 36], identifying and recognizing authors [40], and using reputation and recommendation systems to promote high quality resources [40]. While implementing these strategies might help online communities for CS teachers motivate more experienced teachers to participate, further research is needed to understand how to overcome new teachers' concerns about judgment.

7. CONCLUSION

As additional organizations become involved in training and supporting CS teachers, greater numbers of sites for CS teachers will appear over the coming months and years. Current initiatives to train new CS teachers [14, 22, 27] likely have different challenges than previous models of professional development (PD) because, unlike in other subjects, in CS many teachers have experience teaching another subject and do not have a background in CS [12].

While prior work on online resource sharing sites for CS teachers has largely not mentioned the frequent lack of formal CS training among CS teachers, in our analysis, we found it to be productive to consider the needs of new and experienced teachers separately. We believe that the differences between teachers with and without CS content knowledge have implications for designing and evaluating online CS teacher communities, PD for CS teachers, and CS education research.

In a review of PD programs for CS teachers, PD providers frequently reported that a primary goal was enhancing "participants' understanding of particular CS concepts" [12]. This suggests that in practice PD providers are responding to the lack of content knowledge among new CS teachers. However, central questions remain related to developing best practices for overcoming teachers' lack of background in CS and preparing them to be effective CS teachers.

There is considerable research on knowledge and behavioral differences between novice and expert, i.e., experienced, teachers in many subject areas [52, 53]. However, these models account only for teaching expertise and not for teachers' content knowledge. How these gaps affect the ways in which CS teachers locate, adapt, and share teaching resources is an important area of further inquiry for understanding how to support CS teachers. Building an effective resource sharing site for CS teachers requires both design expertise and knowledge of the teachers who use the site. Understanding teachers' experiences using these resource sharing sites is important for supporting the growing number of CS educators, understanding how teachers adopt new teaching practices, and informing the design of new curriculum sharing sites.

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