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Teachers' Engagement and Self-Efficacy in a PK–12 Computer Science Teacher Virtual Community of Practice

RESEARCH

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ABSTRACT

Prekindergarten to 12th-grade teachers of computer science (CS) face many challenges, including isolation, limited CS professional development resources, and low levels of CS teaching self-efficacy that could be mitigated through communities of practice (CoPs). This study used survey data from 420 PK–12 CS teacher members of a virtual CoP, CS for All Teachers, to examine the needs of these teachers and how CS teaching self-efficacy, community engagement, and sharing behaviors vary by teachers' instructional experiences and school levels taught. Results show that CS teachers primarily join the CoP to gain high-quality pedagogical, assessment, and instructional resources. The study also found that teachers with more CS teaching experience have higher levels of self-efficacy and are more likely to share resources than teachers with less CS teaching experience. Moreover, teachers who instruct students at higher grade levels (middle and high school) have higher levels of CS teaching self-efficacy than do teachers who instruct lower grade levels (elementary school). These results suggest that CoPs can help CS teachers expand their professional networks, gain more professional development resources, and increase CS teaching self-efficacy by creating personalized experiences that consider teaching experience and grade levels taught when guiding teachers to relevant content. This study lays the foundation for future explorations of how CS education–focused CoPs could support the expansion of CS education in PK–12 schools.

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I. BACKGROUND AND LITERATURE REVIEW

In 2013, the American Institutes for Research (AIR) received initial funding from the U.S. Department of Education and later from the National Science Foundation (NSF) to develop a virtual community of practice (VCoP) called the CS10K Community. Although originally focused on creating a virtual home for NSF-funded CS10K projects and their principal investigators, the community rebranded itself as CS for All Teachers to align with President Barack Obama's Computer Science for All initiative (White House, 2016). With this rebranding, CS for All Teachers shifted its central focus from connecting NSF-funded projects together to connecting computer science (CS) teachers of PK–12 together in a VCoP. To combat issues of CS teacher isolation and limited CS resources, CS for All Teachers houses instructional and pedagogical resources, live and asynchronous professional development opportunities, community discussion forums, and expert support from CS teacher leaders. This study examines the needs, perceptions, and behaviors of PK–12 CS teachers within the CS for All Teachers community and identifies practices for CS CoP and professional development designers to increase teacher engagement and teachers' self-efficacy.

CS EDUCATION IN THE UNITED STATES

Because a growing number of jobs require computational skills (Computing Research Association, 2017; Dohm & Shniper, 2007; Finkel, 2012), educators, employers, and students have increasingly recognized the value and necessity of CS education (Century et al., 2013; Google Inc. & Gallup Inc. 2016; Google & Gallup, 2020). CS-related jobs are often attractive because workers receive higher entry-level and median salaries compared to other employment categories (Dohm & Shniper, 2007; U.S. Labor Bureau of Labor Statistics, 2019). The U.S. Bureau of Labor projected that CS-related employment would increase by 12% from 2019 to 2029; in response, many schools have expanded their CS offerings to address a lack of students who can meet increasing workforce demand (*Code.org*, CSTA, & ECEP Alliance, 2020; Goode, 2007; U.S. Bureau of Labor Statistics, 2019). Previous studies have shown that students exposed to high-quality PK–12 CS education are more prepared for CS postsecondary pathways and are more likely to select CS-related majors than are students with limited exposure to CS (*Code.org*, 2016; *Code.org*, CSTA, & ECEP Alliance, 2020; Dougherty, Mellor, & Jian, 2006; Mattern, Shaw, & Ewing, 2011; Yadav, Gretter, Hambrusch, & Sands, 2016).

Although most parents, administrators, and teachers view CS as important to students' future success, less than half of PK–12 schools in the United States directly taught CS or related subjects as of 2020, and only 20 states required that all high schools offer CS (*Code.org*, CSTA, & ECEP Alliance, 2020; Google Inc. & Gallup Inc. 2016; Wilson & Moritz, 2015). Disparate CS teaching certification requirements, limited knowledge of CS content, varying understandings of existing CS content standards, and unclear definitions of CS also make it difficult for teachers to teach CS and for administrators to prioritize CS in their schools (Adrion et al., 2020; Valenzuela, 2019; Wilson & Moritz, 2015). Establishing a pipeline of well-trained and supported PK–12 CS teachers is critical to addressing key barriers to implementing CS instruction and ensure students can meet the needs of the future CS-focused workforce.

CS TEACHER PREPARATION, PROFESSIONAL DEVELOPMENT, AND ONGOING SUPPORT

To deliver high-quality CS education to all students across the United States, we need to ensure CS teachers are well prepared, supported regularly, and connected professionally to one another. However, school districts in the United States have reported struggling to offer CS courses due to the complexities of training or hiring qualified CS teachers (Gal-Ezer & Stephenson, 2010; Google Inc. & Gallup Inc. 2016; Wang, Hong, Ravitz, & Hejazi Moghadam, 2016; Yadav et al., 2016). As of 2020, only 20 states have CS preservice teacher preparation programs at institutions of higher education, which often means that CS teachers must first become certified to teach in other content areas before being allowed to teach CS (*Code.org*, CSTA, & ECEP Alliance, 2020).

Teachers who ultimately receive approval to teach CS face a continuous lack of accessible and high-quality professional development opportunities and resources to aid in improving their CS instruction and assessing student understanding (Valenzuela, 2019; Menekse, 2015; Yadav et al. 2016). CS teacher professional development that does exist is often short in duration (usually lasting about a week in the summer) and only sometimes consists of ongoing engagement during the school year (Archibald, Coggshall, Croft, & Goe, 2011; Darling-Hammond et al., 2017; Google Inc. & Gallup Inc., 2015; Qian, Hambrusch, Yadav, & Gretter, 2018). The one-session professional development structure omits the necessary continuous follow-up and peer discussion needed for CS teachers to properly learn new instructional techniques and can leave teachers without the capacity to improve their practices long term (Berry & Byrd, 2016; Forward, 2011; Lieberman, Miller, Wiedrick, & von Frank, 2011; Menekse, 2015; Qian et al., 2018).

Additionally, those teachers who can teach CS are often the only CS instructor in their schools, contributing to a sense of professional isolation and loneliness (Blikstein, 2018; Century et al., 2013; Ni & Guzdial, 2011; Yadav et al., 2016). This isolation typically deprives CS teachers of the ability to cooperate and share knowledge in the same way as teachers in core subjects (Yadav et al., 2016). Isolation can be compounded by a low sense of CS teachers' self-efficacy—or the strength of teachers' beliefs in their abilities to teach CS. Many CS teachers report low levels of self-efficacy (Yadav et al., 2016), which is related to teachers' institutional practices, occupational satisfaction, and job commitment (Barnes, Crowe, & Schaefer, 2007; Ni & Guzdial, 2011; Ostovar-Nameghi & Sheikhahmadi, 2016; Shernoff et al., 2011). Due to isolation and low self-efficacy, novice CS teachers may not have the time or ability to find materials or mentors to support their CS instruction, and more experienced CS teachers may be hindered by a dearth of opportunities to demonstrate their expertise (Barab, MaKinster, Moore, Cunningham, & the ILF Design Team, 2001; Wixom, 2016). Addressing low teaching self-efficacy and professional isolation in CS teachers is critical to increasing student exposure to CS.

COMMUNITIES OF PRACTICE

Communities of practice (CoPs) are one method to address CS teacher's professional isolation and a lack of high-quality professional development. CoPs are defined as groups of people who consistently, collectively, and collaboratively work toward the goal of improving their practices (Farnsworth, Kleanthous, & Wenger-Trayner, 2016; Wenger-Trayner & Wenger-Trayner, 2015) and are often characterized by a set of shared values and an emphasis on support among peers (Hord, 2004). This method of knowledge sharing started in education and later was adopted in management, with the goal of increasing collaboration among employees (Barwick, Peters, & Boydell, 2009). Recent studies have found that CoPs can help improve peer collaboration, instructional practice, teacher confidence, and classroom management skills (Acar & Yıldız, 2016; Carpenter, Trust, & Krutka, 2016). CoPs are one possible tool to minimize CS teacher isolation, increase peer teacher knowledge sharing, and support the ongoing professional development of CS teachers in content and pedagogy.

Prior literature has identified several effective elements of CoPs. Generally, CoPs function best when topics are relevant to members' daily work, when members feel a shared sense of purpose and ownership, and when members trust one another (Barwick et al., 2009; Dubé, Bourhis, & Jacob, 2005; Forward, 2011; Hemmasi & Csanda, 2009; Wenger-Trayner & Wenger-Trayner, 2015). Prior studies have demonstrated that fostering a culture of sharing and sustained support is critical to CoP success (Barab et al., 2001; Lieberman et al., 2011). CoPs are most effective in increasing content proficiency, classroom management, and high-quality instructional practices when community members frequently interact, collaborate, and exchange feedback with other CoP members (Acar & Yıldız, 2016). Effective CoPs and teaching supports often employ personalized learning and coaching techniques and use data to help establish teacher goals and learning activities (Albulut & Cardak, 2012; Darling-Hammond et al., 2017; Forward, 2011; Ma, Xin, & Du, 2018). Virtual CoPs in particular have an abundance of data to help structure online activities in a way that is personalized, relevant, and useful to members.

Virtual CoPs may be appealing to CS teachers because they typically work independently from other teachers and use online tools to stay connected with other CS teachers (Brown & Kölling, 2013; Qian et al., 2018). Moreover, VCoPs are often nonlinear and asynchronous, allowing for teachers to enter the community from many different avenues without fear of being unprepared or falling behind (Krutka, Carpenter, Trust, 2016). The flexible and collaborative nature of VCoPs may help address common obstacles CS teachers face in implementing high-quality CS instruction. Furthermore, VCoPs can leverage their online nature by using website structure and community features to personalize community members' experiences and promote member engagement and learning (Crutzen, Cyr, & de Vries, 2012; Gynther, 2016; Qian et al., 2018). By adding navigation tools, such as member profile and resource search engines, VCoPs can provide options for teachers to individualize their experiences and quickly connect to the resources and peers they need, further increasing CS teaching self-efficacy (Fincher, Kölling, Utting, Brown, & Stevens, 2010; Qian et al., 2018). Research has suggested that metadata; demographic information; and exposure measures, such as page views, bounce rates, and frequency of visiting, can be used to tailor the structure and content of CoPs or professional development for different community members or participants (Crutzen et al., 2011; Nijland, van Gemert-Pijnen, Kelders, Brandenburg, & Seydel, 2011; Wang & Wu, 2011; Qian et al., 2018).

For example, a VCoP may use user experience designs which limits what resources community members can initially see based on teacher demographics, previously visited resources, and content the user has bookmarked. This allows for teachers to see more relevant content without becoming overwhelmed by all the community's offerings. By personalizing and guiding teachers' learning experiences, teachers can interact within a VCoP in ways that are meaningful, efficient, and relevant to their contexts and learning needs and, subsequently, increase engagement and CS teaching self-efficacy (Qian et al., 2018).

II. CS FOR ALL TEACHERS VCOP

CS for All Teachers is a VCoP, welcoming all teachers of prekindergarten through high school who are interested in teaching CS. The CS for All Teachers community was created to address issues of CS teacher isolation, low CS teaching self-efficacy, limited prior CS training, and scant access to CS professional development. The community aims to connect CS teachers, cultivate high-quality CS instructors, and challenge veteran teachers to support their less experienced colleagues. ***Figure 1*** describes the theoretical framework the CS for All Teachers community uses to guide its development and implementation.

As of December 2020, the CS for All Teachers community has provided its 7,100+ members a variety of services and activities, including pedagogical and instructional resources, webinars, community discussion forums, and expert support from community-sponsored teacher leaders. CS for All Teachers has hosted more than 150 CS-related blog posts, conducted more than 40 live CS education webinars, tallied more than 191,489 pageviews, and crowdsourced more than 1,250 resources. The project team has also hosted four cohorts of teacher leader community ambassadors who contribute resources, blog posts, and webinars to the VCoP, moderate discussion groups, and promote the CS for All Teachers community via social media.

To better serve the community, the CS for All Teachers team started administering an annual survey in 2018 to examine how community members engage with the resources offered and how useful they find these resources. This study, using data from the 2020 survey administration of members, examines the needs, perceptions, and behaviors of PK–12 CS educators within the CS for All Teachers community and identifies effective practices for

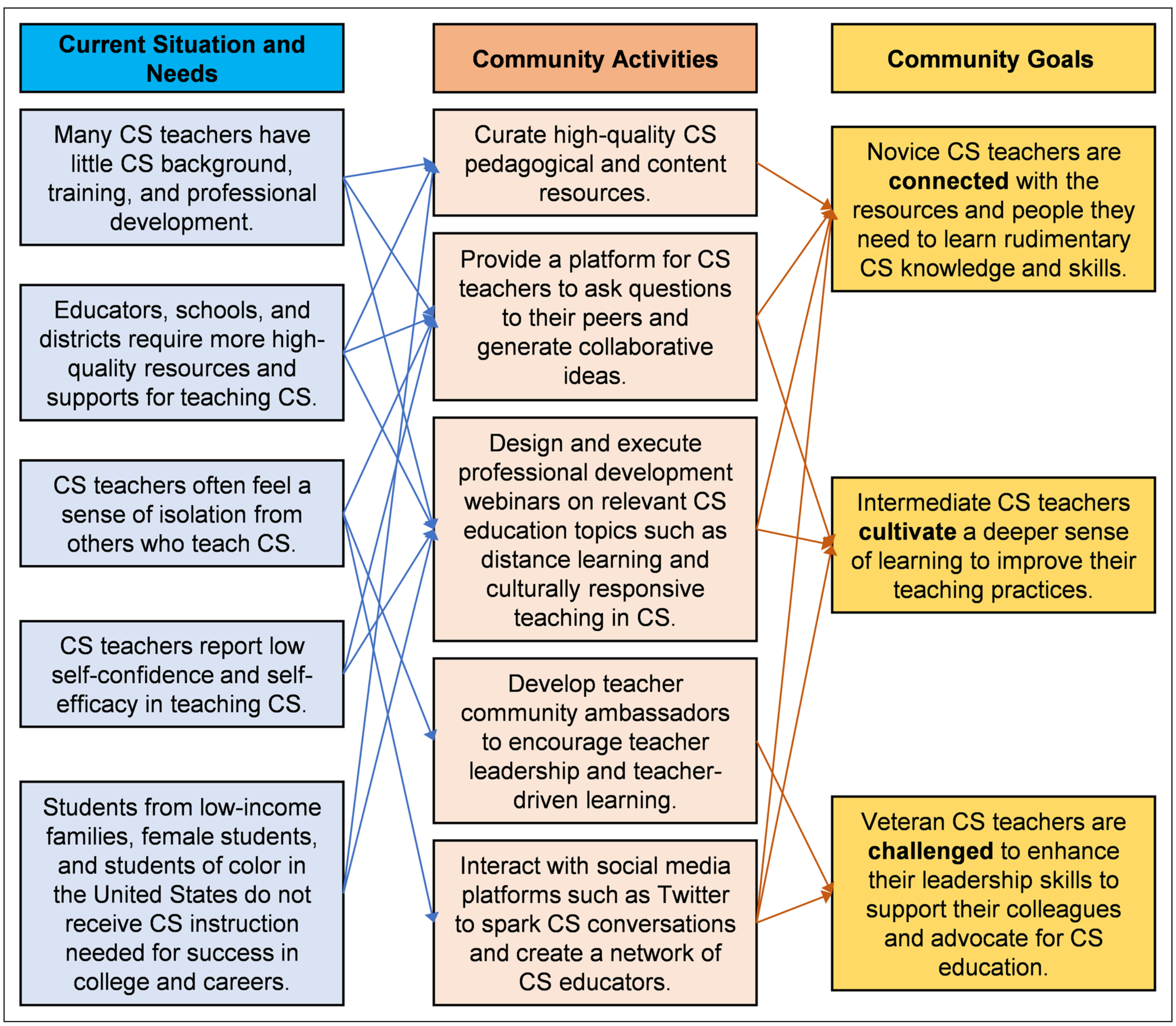

Figure 1 CS for All Teachers Project's Theoretical Framework.

CS CoP and professional development designers to increase teacher engagement and self-efficacy.

III. RESEARCH QUESTIONS

To guide our inquiry, we established the following research questions (RQs) for this study:

RQ1. What are the professional needs and interests of PK–12 teachers within the CS for All Teachers community?
RQ2. What is the relationship between PK–12 CS teachers' satisfaction with the CS for All Teachers community, their community engagement, their perceptions of the community's utility, and their CS teaching self-efficacy?
RQ3. Do PK–12 CS teachers' ratings of community satisfaction, engagement, utility, and CS teaching self-efficacy differ by their levels of overall teaching experience, CS teaching experience, and school level they instruct?
RQ4. Do PK–12 CS teachers' reports of sharing resources and learning new things to improve their CS instruction in the CS for All Teachers community differ by their level of overall teaching experience, CS teaching experience, and the school level they instruct?

IV. METHODS

DATA COLLECTION

In April 2020, the CS for All Teachers team administered a survey to the community members regarding their experiences of participation in activities and services provided by the community. The survey asks questions related to community members' interests with respect to CS education, their perception of the community and their reasoning for joining the community, as well as their self-efficacy and beliefs in CS teaching. The research team sent an individualized link to a total of 1,355 community members who logged in to the community website (*csforallteachers.org*) at least once in 2019–20 and consented to survey research activities. The CS for All Teachers team posted a blog announcing the survey and distributed a monthly newsletter to members who opted in, which gave members who were not initially selected the chance to request participation in the survey.

STUDY SAMPLE

A total of 559 respondents completed the survey, yielding a 41% response rate (559/1,355 eligible community members). This response rate is considered sufficient for the electronic survey data to be used as evidence for evaluation and improvement purposes (Nulty, 2008). Respondents were asked to describe themselves professionally by selecting all applicable professional roles, such as elementary, middle, and high school teacher; researcher; and school administrator. This study focuses on PK–12 teachers; therefore, those respondents who did not select a PK–12 professional teaching role (n = 139) were excluded from our sample, which left 420 respondents in the final study sample.

The demographics of the study participants in the sample are displayed in ***Table 1***. Most participants were female (69%) and White (74%), have an advanced degree beyond a bachelor's degree (78%), and teach at the high school level (63%). In addition, most participants (87%) had more than 5 years of overall teaching experience, and 86% of participants had 5 years or fewer of CS teaching experience. The sample includes teachers from all school levels, with those teachers teaching only high school (63%), only middle school (13%), and only elementary school (7%).

Some teachers taught across multiple school levels. For example, some teachers taught at both elementary

DEMOGRAPHIC CHARACTERISTICS OF SAMPLE	*N*	%
Race and ethnicity		
American Indian or Alaska Native	1	0.2%
Asian	20	4.5%
Black or African American	49	11.0%
Hispanic or Latino/a/x	21	4.7%
Native Hawaiian or other Pacific Islander	1	0.2%
White	332	74.3%
Other	7	1.6%
Two or more races	16	3.6%
Gender		
Male	137	30.3%
Female	312	69.0%
Other	3	0.7%
School level(s) taught		
Elementary	30	7.1%
Elementary & middle	16	3.8%
Middle	54	12.9%
Middle & high	47	11.2%
High	264	62.9%
All	9	2.1%

(Contd.)

DEMOGRAPHIC CHARACTERISTICS OF SAMPLE	*N*	%
Age		
18–24	8	1.7%
25–29	11	2.4%
30–34	37	7.9%
35–39	35	7.5%
40–44	65	13.9%
45–49	90	19.3%
50–54	102	21.9%
55–59	70	15.0%
60–64	32	6.9%
65+	16	3.4%
Highest level of educational attainment		
Bachelor's degree (e.g., BA, BS) or lower	92	22.1%
Graduate degree beyond bachelor's degree	324	77.9%
CS teaching experience		
None	11	2.4%
Less than 1 year	44	9.4%
1–2 years	80	17.1%
3–5 years	163	34.8%
6–10 years	99	21.2%
11–20 years	44	9.4%
21 or more years	27	5.8%
Overall teaching experience		
None	2	0.4%
Less than 1 year	3	0.6%
1–2 years	17	3.6%
3–5 years	42	8.9%
6–10 years	75	15.9%
11–20 years	187	39.6%
21 or more years	146	30.9%

Table 1 Characteristics of Analytic Sample (*N* = 420).

and middle school levels (3.8%), other teachers taught at both middle and high school levels (11.2%), and some teachers taught at all three levels of schooling (2.1%). When examining a cross-tabulation between CS and overall teaching experience, more than 70% of the participants were novice (have 5 or fewer years of experience) teachers in CS but veteran (have more than 5 years of experience) teachers overall (see **Table 2** in **Appendix A**).

MEASURES

The study team constructed scales to measure community satisfaction, community engagement, community utility, and CS teachers' self-efficacy. This section describes these scales, and the details of the scale items are presented in **Appendix B**.

Community satisfaction

Participants were asked to rate their agreement with a list of statements about the community on a 4-point Likert scale: Strongly Disagree (1), Disagree (2), Agree (3), and Strongly Agree (4). The following are some of the statements: "Using the community website is enjoyable," "The community's content is relevant to me," and "I would recommend the community to a colleague."

Community engagement

Participants were asked to indicate how often they had engaged with certain aspects of the community on a 5-point Likert scale: Never (1), Once in the Past 6 Months (2), Monthly (3), Weekly (4), and Daily (5). These aspects related to a variety of community activities, such as visiting the CS for All Teachers website, accessing member- specific content, and participating in webinars.

Community utility

The CS for All Teachers community offers a wide variety of activities, such as blog posts, tweets, networking events, and webinars, to its community members. Participants were asked to rate the usefulness of these activities on a 4-point Likert scale: Never Used (1), Not Useful (2), Somewhat Useful (3), and Very Useful (4).[1]

Self-efficacy

AIR drew from the Teaching Efficacy and Beliefs scale of Teacher Efficacy and Attitudes Toward STEM (science, technology, engineering, and mathematics) Survey (Friday Institute for Educational Innovation, 2012) to create the CS teachers' self-efficacy scale. Survey participants were asked to rate their agreement with items related to their self-efficacy and confidence in teaching CS on a 4-point Likert scale: Strongly Disagree (1), Disagree (2), Agree (3), and Strongly Agree (4). The Teaching Efficacy and Beliefs scale has been validated by the Friday Institute for Educational Innovation with Cronbach alpha reliabilities above 0.90 across STEM fields (Friday Institute for Educational Innovation, 2012).

Sharing behaviors and knowledge acquisition

Participants were asked to select either Yes (0) or No (1) on two questions. The first question was about content sharing: "Do you share the resources, discussions, and events from the community with others?" The second question focused on knowledge acquisition: "Have you learned new things through the community that have changed your understanding of teaching computer science?"

DATA ANALYSES

Rasch analysis

Teacher survey items were scaled using the Rasch model for ordered response categories (Andrich, 1978; Rasch, 1980; Wright & Masters, 1982) to determine whether the items reliably measured constructs they were intended to measure. Items that were designed to measure a single underlying construct, such as CS Teaching Self-Efficacy, were scaled together. The scale scores provided a quantitative view of the frequency and intensity of participants' answers across a set of items representing a given construct. These scale scores were then used in analyses to answer different research questions.

In addition to the scale scores, the Rasch analysis yielded several statistics that allow for assessment of reliability and validity. Here, we focused on two statistics: Cronbach's alpha statistic and item fit. Cronbach's alpha measured how well a set of items were internally consistent. Item fit indicated the extent to which the item fit with other items to measure the underlying construct. Infit and outfit mean-square values were used to identify good-fit and misfit items.

Correlation and regression analyses

To answer RQ1 (What are the professional needs and interests of PK–12 teachers within the CS for All Teachers community?), the CS for All Teachers research team calculated response distributions for survey items regarding reasons for joining the community and the biggest challenges of CS instruction. To answer RQ2 (What is the relationship between PK–12 CS teachers' satisfaction with the CS for All Teachers community, their community engagement, their perceptions of the community's utility, and their CS teaching self-efficacy?), the project team conducted a series of Pearson product-moment correlation analyses. To answer RQ3 about whether the four constructs (Community Satisfaction, Community Engagement, Community Utility, and CS Teaching Self-Efficacy) differ by members' teaching experiences and school levels they instruct, the project team conducted a multiple linear regression analysis. To answer RQ4 about whether members' sharing and networking behaviors differ by their teaching experiences and school levels they instruct, the research team conducted a multiple logistic regression analysis.[2] Teacher-level characteristics, such as gender, race/ethnicity, age, and highest level of educational attainment, were added as covariates in these regression models. See **Appendix D** for more details about these regression models.

To prepare the data for analyses, the project team recoded multiple variables, such as age, race/ethnicity, and teaching experience, to ease the difficulty of running the regression models.

For example, the racial groups American Indian or Alaska Native, Asian, Black or African American, Hispanic or Latino/a/x, Native Hawaiian or other Pacific Islander, and Two or More Races were combined together as Non-White due to the small number of participants in each of the groups. See **Appendix C** for more details about the coding scheme. Pairwise deletion was applied across all analyses, resulting in each analysis excluding cases that did not have valid data on variables of interest.

V. RESULTS

RASCH ANALYSIS

Based on the cut value of mean square of infit and outfit parameters (Linacre, 2010), no misfitting items were detected for the three constructs (Community Satisfaction, Community Engagement, and Community Utility), and the items individually functioned well. One item of the construct CS Teaching Self-Efficacy (*I wonder if I have the necessary skills to teach CS*) was found to be misfitting, possibly because it was negatively worded, and the other items were all positively worded. Rasch analysis was conducted for the construct CS Teaching Self-Efficacy again after this item was removed, and no misfitting items were detected.

The Cronbach's alpha reliability was 0.99, 0.99, 0.84, and 0.98 for the four constructs, Community Satisfaction, Community Engagement, Community Utility, and CS Teaching Self-Efficacy, respectively. These values were all above 0.7, the acceptable reliability coefficient threshold (Nunnaly, 1978), providing the reliability evidence for these measures, as well as the support to use the scales scores in analyses to answer RQs 2, 3, and 4.

RQ1. WHAT ARE THE NEEDS AND INTERESTS OF PK–12 TEACHERS WITHIN THE CS FOR ALL TEACHERSCOMMUNITY?

Participants were asked to report their top reasons for joining the CS for All Teachers community and their biggest challenges to CS instruction. The research team used the data collected to better understand teacher motivation and what challenges teachers may face in their CS instruction. Taken together, these questions provided more detailed insights into the needs and interests of PK–12 teachers in the CS for All Teachers community.

The reasons why teachers join the CS for All Teachers Community

The three most popular choices for joining the community included "Being a teacher of computer science" (75%), "Looking for computer science education resources and materials that I can use" (69%), and "Looking for information and/or resources on computer science in high school" (39%). The fourth most popular choice was about connecting with others interested in computer science (31%; see **Table 3** in Appendix A for more details about the results).

The biggest challenges for CS instruction

The three biggest challenges for CS instruction identified by participants included "Finding and using assessments of student learning for computer science and computational thinking" (55%), "Finding and using lesson plans or curricular units around specific topics" (43%), and "Finding and using best practices for organizing instruction for lessons in computational thinking or computer science" (39%; see **Table 4** in Appendix A for more details about the results).

RQ2. WHAT IS THE RELATIONSHIP BETWEEN PK–12 TEACHER MEMBERS' SATISFACTION WITH THE COMMUNITY, THEIR PERCEPTIONS OF THE COMMUNITY'S UTILITY, AND THEIR COMMUNITY ENGAGEMENT?

A series of Pearson product-moment correlation analyses were conducted to assess the relationships between teacher self-reports of community satisfaction, community engagement, community utility, and CS teachers' self-efficacy. The results showed CS teachers' self-efficacy was positively correlated with community satisfaction, community engagement, and community utility, and the correlations were statistically significant although weak (see **Table 5** in Appendix A for more details about the results). Community engagement was positively correlated with community satisfaction and community utility, and the correlations were also statistically significant although weak. A statistically significant, moderate, and positive correlation was found between community utility and community satisfaction.

RQ3. DO PK–12 TEACHER COMMUNITY MEMBERS' RATINGS OF SATISFACTION, COMMUNITY ENGAGEMENT, UTILITY, AND CS TEACHING SELF-EFFICACY DIFFER BY THEIR LEVELS OF OVERALL TEACHING EXPERIENCE, CS TEACHING EXPERIENCE, AND SCHOOL LEVEL TEACHERS INSTRUCT?

To answer RQ3, a multiple linear regression analysis was conducted separately for the four constructs as the outcome: Community Satisfaction, Community Engagement, Community Utility, and CS Teaching Self-Efficacy. Teacher-level characteristics, including age, highest level of educational attainment, race/ethnicity, and gender, were used in the models as covariates.

The variables of interest—school level taught, CS teaching experience, and overall teaching experience—were included in the models as independent variables.

The results show veteran (more than 5 years of experience) CS teachers reported significantly higher CS teaching self-efficacy than did novice (5 or fewer years of experience) CS teachers (see **Table 6** in Appendix A for more details about the results). Teachers who taught both middle and high school grades and teachers who taught only high school grades reported significantly higher CS teaching self-efficacy than did teachers who taught just elementary school grades. Tukey's comparison of means post-hoc analyses were conducted, and the results showed teachers who taught only middle school reported lower CS teaching self-efficacy than did teachers who taught both middle and high school, and the difference was statistically significant. No difference was found for the other three outcomes: Community Satisfaction, Community Engagement, and Community Utility (see **Tables 7–10** in **Appendix A** for more details about these results).

RQ4. DO PK–12 TEACHER COMMUNITY MEMBERS' REPORTS OF SHARING RESOURCES AND LEARNING NEW THINGS TO IMPROVE THEIR CS INSTRUCTION DIFFER BY THEIR LEVEL OF OVERALL TEACHING EXPERIENCE, CS TEACHING EXPERIENCE, AND THE SCHOOL LEVEL TEACHERS INSTRUCT?

To answer RQ4, a multiple logistic regression was conducted separately for two survey questions, with binary response options as the dependent variable. The two questions were the following: "Do you share the resources, discussions, and events from the community with others?" and "Have you learned new things through the community that have changed your understanding of teaching computer science?" Participants selected either Yes (1) or No (0) to each of the two questions. Teacher-level characteristics, including age, highest level of educational attainment, race/ethnicity, and gender, were used in the models as covariates. The variables of interest—school level taught, CS teaching experience, and overall teaching experience—were included in the models as independent variables.

The analysis results showed veteran CS teachers were 21% more likely to report sharing resources, discussions, and events from the community with others than novice CS teachers, and the difference is significant. No difference was found for the outcome of learning CS through the community. See **Tables 10** and **11** in **Appendix A** for more details about these results.

VI. DISCUSSION AND IMPLICATIONS

The current study used survey data from 420 PK–12 CS teacher members of the CS for All Teachers VCoP to examine the needs of teacher members and how CS teaching self-efficacy, community engagement, and sharing behaviors vary by teachers' instructional experiences and school levels taught. The findings support the idea that teaching experience and grade level taught are key factors to consider when engaging CS teachers in CoPs (Yadav et al., 2016; Qian et al., 2018). CoPs can help bolster engagement, address teachers' lack of high-quality CS resources, and increase CS teaching self-efficacy by creating personalized experiences that leverage teacher data and emphasize accessibility, relevancy, and connectivity.

PK–12 CS TEACHERS' PROFESSIONAL NEEDS AND INTERESTS

PK–12 teacher members reported that a lack of CS teaching experience, limited CS instructional resources, and isolation from other CS teachers were primary motivators to join and engage with the CS for All Teachers community. Many teacher members also reported generally having trouble finding CS learning assessments, curriculum materials, and best practices for CS instruction. These findings echo past literature, which found that CS CoP members primarily engage with CoPs to gain high-quality CS pedagogical, assessment, and instructional resources (Yadav et al., 2016).

CORRELATION BETWEEN COMMUNITY ENGAGEMENT, SATISFACTION, AND UTILITY

The research team found positive correlations between teacher members' community satisfaction and community engagement and their perceptions of community utility. Teacher motivation to find high-quality CS resources may help provide context for understanding these positive correlations. Because PK–12 CS teachers primarily use the CS for All Teachers community to find resources, the quality, perceived relevance, ease of use, and accessibility of CS resources may be essential to community engagement. This finding aligns with past literature, which found that learning community engagement is related to teachers' perceived value and relevance of community offerings (Dubé et al., 2005; Zhang & Liu, 2019). Prior literature has demonstrated that even when CS teachers can find applicable resource repositories, they often have a hard time effectively navigating the repositories for relevant content (Yadav et al., 2016). Consequently, simply collecting high-quality resources may not be enough to drive community engagement and the implementation of high-quality CS instruction. Findings from this study suggest it is necessary for CS VCoPs to leverage teacher data to personalize the VCoP experience and efficiently present teachers with highly relevant resources. For example, a VCoP may personalize CS teachers' experiences by directing new CS teachers to a collection of premade beginner lessons and directing veteran CS teachers to resources on individualizing student CS instruction or creating a school wide CS program. Moreover, VCoPs can use member demographic data such as grade levels members instruct and members' current location to recommend relevant content that aligns with state standards and grade level. By making resources easy to find and quickly understandable, VCoPs can remove barriers to implementing CS instruction.

TEACHING EXPERIENCE AND TEACHERS' SELF-EFFICACY

Most participants in the current study are novice CS teachers (5 years or fewer of experience) but are veteran teachers overall (more than 5 years of experience). Veteran CS teachers in the CS for All Teachers community were found to have higher levels of CS teaching self-efficacy and were more likely to share community resources than were novice CS teachers. These findings align with prior literature, which found that CS teachers' self-efficacy develops as teachers gain more successful experiences in their instructional practices (Rich, Jones, Belikov, Yoshikawa, & Perkins, 2017) and that teachers who have more practical instructional experience are more likely to share their insights than are less experienced teachers (Khe Foon Hew & Noriko Hara, 2007). These results also emphasize that VCoPs should leverage teacher data to facilitate collaboration between novice and veteran CS teachers. For example, a VCoP might use recommendation engines and live content feeds to highlight discussions that have a high volume of comments from veteran teachers to novice CS teachers. By facilitating connections through personalizing the teacher experience, VCoPs can help establish collective responsibility and capitalize on veteran teachers' propensities to share community resources (Lieberman et al., 2011).

Few CS teachers have gone through dedicated CS-focused preservice programs, but most CS teachers do have a wealth of teaching experience in other domains. By facilitating interdisciplinary connections between CS and other domains, VCoPs can leverage teachers' overall teaching experiences to improve the integration of CS into classrooms. Prior research has found that teachers who successfully implemented even one computing-based lesson had increased CS teaching self-efficacy and were more likely to implement more computing-related lessons in the future (Rich et al., 2017). By customizing community members' experiences to make the CoP more relevant and intuitive, community members may increase their CS teaching self-efficacy by finding and implementing more CS lessons in their classrooms (Qian et al., 2018).

GRADE LEVEL TAUGHT AND CS TEACHERS' SELF-EFFICACY

The current study found that CS teachers who taught at higher grade levels had a higher level of self-efficacy than did CS teachers who taught at lower grade levels. This difference may partially be due to fewer dedicated CS courses offered at elementary schools compared to middle and high schools (Google Inc. & Gallup Inc., 2016). Elementary school CS teachers may also have a lower level of self-efficacy due to lack of CS training, curriculum standards, and resources compared to the availability of those items for middle and high school teachers (Google Inc. & Gallup Inc., 2016; Rich et al., 2017). These findings echo previous literature, which found that elementary teachers lack confidence in teaching STEM subjects and can be apprehensive to implement new STEM-related curricula (Hammack & Ivey, 2017). Additionally, elementary school teachers are reluctant to implement STEM into their classrooms due to strong incentives for instruction to clearly align with standardized testing outcomes (Watson, Williams-Duncan, & Peters, 2020). These findings affirm that school-level context can affect CS teachers' self-efficacy and emphasize the need for more CS resources for elementary and middle school CS teachers.

CS education support providers need to recognize the unique demands put on CS teachers at each level of schooling and create tools to help teachers navigate the VCoP or professional development in ways that are meaningful to various types of CS teachers (Fincher et al., 2010).

VCoPs can create personalized experiences through which teachers of different grade levels collaborate efficiently and intuitively to find highly relevant resources. For example, a personalized experience for novice elementary school teachers may incorporate user interface elements to direct community members toward resources with short, easy, and low-risk ways to implement CS. This pathway may also guide users to group discussions about CS interventions that have comments from veteran elementary CS teachers. By creating differentiated experiences within the community that emphasize accessibility, relevancy, and efficiency for all types of CS teachers, VCoPs can address teachers' lack of high-quality CS resources and low CS teaching self-efficacy.

VII. LIMITATIONS

Interpretation of the results should be viewed within the limitations and delimitations of the study. Although the study found several significant relationships (e.g., CS teachers' self-efficacy and CS teaching experience, CS teachers' self-efficacy and school level of instruction, community engagement and community satisfaction), they are all correlational and should not be interpreted as causal–effect relationships. This study also relied entirely on PK–12 self-reported survey data and did not use any community website activity data or classroom observations to capture how teachers' observed behaviors may vary from self-reported data. Several analyses in the study also were subject to relatively low sample sizes, with some models containing fewer than 300 cases in the analytic sample. Future research could strive to examine a larger sample, link self-reported and observation data, and employ research designs that permit strong casual inferences.

CONCLUSION

By analyzing community members' responses to survey items, the current study aimed to understand the most pressing needs of PK–12 CS teachers and how CS teaching self-efficacy, community engagement, and resource-sharing behaviors vary by teachers' instructional experiences and school levels taught. The current study found that teachers with more CS teaching experience have higher levels of CS teaching self-efficacy and are more likely to share resources from the CS for All Teachers community than are teachers with less CS teaching experience. Moreover, CS teachers who instruct students at higher grade levels (middle and high school) have higher levels of CS teaching self-efficacy than teachers who instruct at lower grade levels (elementary school). VCoPs should therefore consider leveraging teacher data and create personalized experiences within their online spaces to intuitively guide teachers through the community, considering teachers' years of experience and school levels taught. These personalized experiences should not only clearly direct teachers to relevant resources based on their needs and contexts, but should also consistently connect teachers with different backgrounds to capitalize on veteran teachers' propensities to share resources and on middle and high school CS teachers' higher levels of CS teaching self-efficacy. Through recognizing the unique needs and contexts of CS teachers of different experiences and grade levels, VCoPs can individualize the teacher experience, increase community engagement, and make CS resources intuitive to find, easy to implement, and convenient to share for all types of CS teachers.

NOTES

1 The option Never Used was treated as missing during the survey analysis.

2 The response to questions regarding members' behaviors such as sharing resources and connecting with others is binary (i.e., 1 if selected Yes and 0 if selected No) and therefore a logistical regression was used during the analyses.

ADDITIONAL FILES

The additional files for this article can be found as follows:

- **Appendix A.** Analysis Results. DOI: *https://doi.org/10.26716/jcsi.2021.10.8.34.s1*
- **Appendix B.** CS for All Teachers Survey Item Response Distribution Tables. DOI: *https://doi.org/10.26716/jcsi.2021.10.8.34.s2*
- **Appendix C.** Coding Scheme for Data Analyses. DOI: *https://doi.org/10.26716/jcsi.2021.10.8.34.s3*
- **Appendix D.** Multiple Regression Models. DOI: *https://doi.org/10.26716/jcsi.2021.10.8.34.s4*

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