Preparing and Supporting Industry Professionals as Volunteer High School Computer Science Co-Instructors

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ABSTRACT

The rapid expansion of computer science (CS) education across the United States has left schools struggling to find teachers for CS classrooms. One approach to supplementing school and teacher expertise is to use industry professionals as volunteers in the classroom. This paper outlines the model of recruiting, training, and supporting volunteers in CS classrooms used by TEALS, a national computer science education program that creates co-teaching partnerships between industry experts and educators. This paper presents detailed information about the volunteers and the training the they receive, as well as the impact and outcomes on the students and cooperating teachers. Results from teacher, student, and volunteer surveys show satisfaction with the volunteers, as well as continued growth in perceived volunteer classroom performance over the year.

CCS Concepts

•**Social and professional topics** → **Computing education;**

Keywords

Industry Volunteers; CS4All; K12 CS Education

1. INTRODUCTION

Studying computer science prepares students for in-demand careers in the tech industry and teaches them computational thinking and problem-solving skills applicable to many future career paths. Yet, computer science (CS) is taught in only 25% of high schools in the United States [7]. Companies across all industry sectors are seeking a growing number of people with computer science and computer engineering skills. Teaching Advanced Placement (AP) or Introductory

CS courses requires deep content knowledge, and the ability to provide students with direct examples requires field experience [7].

Leveraging the knowledge and expertise of computer science professionals provides one approach to addressing this challenge. Simply placing professionals with content knowledge in classrooms does not yield the same results as trained teachers [4]. However, professionals can be paired with a teacher to provide benefit to classrooms, as demonstrated in science classrooms in [5].

Volunteer programs have been shown to be efficacious in producing student outcomes similar to national averages [3]. One such program is TEALS, a national computer science education program that creates co-teaching partnerships between industry experts and educators. In this paper, we describe the TEALS program (Section 2), the profile of TEALS volunteers (Section 3), their recruitment and selection (Section 4), the training they receive before and during their time in the classroom (Section 5), and outcomes reported from both the volunteers themselves and the partner schools.

2. TEALS AND VOLUNTEERS

2.1 The TEALS Program

Since its inception, TEALS has partnered with 305 high schools in 26 U.S. states and Washington, D.C., to build computer science teacher capacity and grow sustainable computer science programs [3].

The TEALS program provides a high-touch professional development model for high school teachers to learn computer science by placing trained technology industry professionals into their classrooms as volunteer co-instructors. Professional-based volunteer opportunities have long been a part of other industries; TEALS provides an opportunity for computer science professionals to use their core programming skills in a philanthropic manner by helping high schools build the teacher capacity necessary for a sustainable CS program. In this collaborative partnership, teachers bring their expertise in student development and educational theory to ensure volunteers have a successful and dynamic classroom environment.

2.2 Use of Volunteers in Educational Settings

TEALS requires a pool of tech-savvy volunteers willing to commit large amounts of time to further the cause of

CS education. TEALS necessarily focuses on recruitment, training, and retention of volunteers to grow the program. Creating and maintaining lasting relationships with volunteers requires identifying and understanding key predictors of continued volunteer engagement. For instance, to retain volunteers, TEALS must understand why individuals decide to volunteer, what encourages them to maintain their commitment, and what limits their future engagement [2].

Motivation is a factor in determining initial interest in volunteering, but organizations are more likely to see long-term service commitments when volunteers think of their role as part of a personal identity [1]. The ways in which a volunteer feels connected to an organization influence both their satisfaction with the experience and their longevity. The "duration of volunteer service can be understood as duration of service in an organization, so that it is logical to suppose that length of service will be influenced by organizational variables" [1] (p. 629). While motivation and satisfaction help predict continued volunteer engagement in short-term opportunities (less than 12 months), organizational commitment, not satisfaction, is proposed as the key predictor of volunteering intention and behavior in long-term opportunities [1]. The quality of "various interactional aspects of the organization content and context" are considered to be additional accurate indicators [2].

The success of TEALS specifically relies on the commitment of the school and school district and the participation of the classroom teacher. Teachers have years of experience and training in classroom management and know how to challenge and support students effectively [5]. Teachers understand and can enforce district and school policies and procedures, manage disciplinary interventions, and often have an ongoing relationship with students, thereby understanding how to appropriately engage with them in the classroom.

A successful teacher will create a classroom that promotes critical thinking by utilizing effective educational methods including varied questioning and testing techniques and multimodal instruction. Effective teaching requires building upon concepts using a variety of presentation styles and focused discussion [6]. The importance of non-verbal cues while teaching is also vital to an open and engaging classroom. Providing training and practice on body language, vocal inflection and tone, eye contact, and non-verbal presence is vital to volunteers' success working with students [6]. While TEALS volunteers have valuable real-world experience working in the subject area of computer science, TEALS conducts extensive training in the areas referenced above to prepare volunteers for their work with students.

3. TEALS VOLUNTEERS

3.1 TEALS Volunteer Roles

TEALS volunteers serve as part of a team led by a licensed classroom teacher. Volunteers work directly with students in the class and help prepare the teacher to eventually teach computer science without volunteer support. TEALS requires that volunteers commit to an entire year of service. This commitment includes regular classroom visits, attending summer training, and participating in team and program meetings. In 2016/2017, TEALS offered three explicitly-labeled engagement models to support high school teachers.

Co-Teaching: The co-teaching model affords the greatest level of support and targets teachers with limited or no computer science content knowledge. In this model, TEALS assigns four volunteers to partner with a single classroom teacher as a teaching team. Each volunteer commits to attend class twice per week, so that at least one volunteer is present each day. The classroom teacher handles classroom management and working with students who have special needs. The teaching team collaborates on preparing and leading lessons, assisting individual students, and grading. Two of the four volunteers are assigned to the volunteer teaching role, while the other two serve as teaching assistants (TAs). Volunteer teachers prioritize preparing and leading lessons using the TEALS curriculum materials, while TAs support the instructors, assist students with their lab work, and grade assignments. Volunteers indicate preferred roles on their application, but the TEALS staff make the final role assignments after interviewing the volunteer candidates.

Teaching Assistants (TA): Classroom teachers who begin to develop enough comfort and expertise with the curriculum, or those who come to the program with a level of experience with CS, can enter the TA support model. In this model, two volunteers support one section of a computer science class, each visiting twice per week. TAs provide guidance and support for the classroom teacher as they progress through the curriculum, help individual students with their assignments, and assist the teacher with grading student work. TAs help experienced CS teachers add industry exposure, build excitement for CS at their school, and provide a safety net for teachers who are still learning the material.

Consulting Support: Once a classroom teacher is confident with the curriculum, or if a school hires a teacher with CS experience, TEALS can provide a volunteer as an offline resource for the classroom teacher. This volunteer can answer questions by phone or email and visit the classroom occasionally to present a real-world perspective. The consulting support model demonstrates sustainability in computer science education, as it is proof that the classroom teacher has confidence and the ability to instruct students independently.

3.2 TEALS Volunteer Profile

To apply to volunteer with TEALS, individuals must have academic or professional experience with computer science. Volunteers represent a cross-section of the computer science community, including recent CS graduates eager to share their enthusiasm for the field, as well as seasoned professionals who want to give back to their communities and help increase interest of young people. While TEALS provides training on instructional techniques and classroom management, volunteer applicants must demonstrate affinity for teaching. Candidates with previous education experience or other volunteerism are given preference.

The following is an overview of TEALS volunteer demographic data, compiled from the applications of volunteers accepted to the program for the 2016-17 school year:

- **Gender**: 75% identify as male and 25% identify as female.

- **Employment**: Volunteers represent 300 different organizations nationwide.

- **Experience**: 42% of volunteers have spent 11+ years

in the CS field. 38% have been in the field for less than 5 years.

- **Education**: 90% of volunteers report earning a bachelor's degree in computer science, engineering, or a related field. 25% of the applicant pool have earned a graduate degree in such a field.

Volunteers write about their motivations to volunteer in the TEALS application and again in an end-of-year survey. Volunteers stated that they found great motivation in teaching or in working with students (see Table 1). TEALS volunteers understand the value of early exposure to CS and want to lend their professional expertise. One volunteer explained that "learning to program at a young age will benefit students in many ways in the rest of their lives, even if they don't choose to pursue a major or career in programming." Many volunteers are also grateful for the opportunities afforded to them through CS and want to bring those benefits to students who might not otherwise be aware of the positive socioeconomic impacts of a CS career. A volunteer shared that TEALS "makes a difference in students' lives. I am doing well as a Software Engineer and it would be amiss if I don't pass this opportunity onto others."

Table 1: TEALS Volunteer Motivations

For Students	25%
Pay It Forward	20%
Enjoy Teaching	20%
Personal Satisfaction	19%
Personal Skill Development	10%

4. VOLUNTEER RECRUITMENT AND SELECTION

4.1 Volunteer Recruitment

TEALS runs a volunteer recruitment campaign that incorporates word of mouth, direct outreach, and social media to promote the program and find volunteers. TEALS recruits through a network of relationships established by the program's founder as well as by program staff, school partners, community leaders, program alumni, and veteran volunteers. Application data indicates that more than half of volunteer applicants learn about TEALS by way of word of mouth from current volunteers, schools, former students, university alumni networks, and other channels. Social media is also a significant tool in the volunteer recruitment cycle, accounting for 12% of the applications received (see Table 2).

Throughout the recruitment cycle, TEALS staff conduct recruitment activities at companies across the country. The message to potential volunteers is "Teach CS. Keep your day job." and is conveyed through social media, email blasts, and in-person information sessions. Information sessions educate the audience on the talent shortage facing industry and the state of CS education in U.S. and local high schools. Presenters introduce the TEALS model and highlight volunteer experiences. Potential volunteers seem to appreciate the combination of personal interaction with concrete data. Throughout recruitment, TEALS emphasizes the time commitment required of volunteers in an effort to minimize withdrawals from the program.

Table 2: Top Sources of New Applications

Organic Referrals	46%
Social Media	12%
Web Search	6%
Print Materials	6%

4.2 Volunteer Selection

TEALS runs an extensive application and screening process to assess volunteer interest and fit. TEALS regional managers conduct in-person interviews of all candidates to assess technical expertise and basic teaching competence, review expectations and commitments, and answer candidates' questions about the program. The regional managers are also responsible for technical recruiting and relationship management of local volunteers. After the interviews, regional managers select volunteers for acceptance and place them into teaching teams, balancing the needs of partner schools with various preferences indicated by each candidate's application.

4.3 Volunteer Retention and Engagement

Of individuals who volunteered for the 2015-16 school year, 47% returned for 2016-17. It is difficult to establish a baseline for comparison of this retention rate due to TEALS' unique program model. Table 3 outlines common reasons volunteers do not sign up for a second year teaching with TEALS.

Table 3: Why TEALS Volunteers Don't Reapply

Time Commitment	38%
Life Changes	19%
Program Challenges	10%
School Challenges	10%
Taking A Break	8%

In previous years, volunteers have cited curriculum materials and training as points of frustration. Intensive focus on these areas has led to improved retention and increased satisfaction. TEALS continues to examine and improve factors within its control.

TEALS ensures that volunteers receive frequent and personalized attention and support. Staff host monthly regional meetings that provide social engagement and ongoing professional development related to teaching computer science. Topics have included a discussion on effective remote teaching techniques, classroom management strategies, tips and tricks for preparing students the AP exam, and uses of formative assessment.

Regional TEALS staff also conduct classroom observations and offer direct feedback and guidance to improve volunteers' teaching. TEALS staff also create informal meeting opportunities (e.g. over lunch) to allow for an extended conversation and to show appreciation by treating the volunteers to a meal.

Access to an online curriculum repository and online discussion forum were both noted by volunteers as extremely useful. In the anonymous 2015-16 end-of-year program survey, 60% of respondents found the discussion forum useful and 78% of respondents said that they found use in the curriculum repository.

Table 4: Outline of TEALS Training Lessons

Key: IP 1 = In Person Session 1, IP 2 = In Person Session 2, IP 3 = In Person Session 3, OL = Online

Topic	Format	Instruction Time	Activity Time	Total Time
Student-centered Learning/Learning Objectives/Bloom's Taxonomy	IP 1	10	10	20
Hello World	IP 1	0	10	10
Anatomy of a Lesson Plan	IP 1	10	10	20
Presenting New Content/Whiteboarding Techniques	IP 1	20	10	30
Discussion and Questioning Techniques	IP 1	20	0	20
Responding to Questions and Answers	IP 1	10	10	20
CS Unplugged/Demos	IP 1	25	5	30
Worked Examples	IP 1	10	5	15
Formative Assessment/Setting Clear Expectations	IP 1	15	0	15
4 Steps to Solve Any Problem/Helping Students with Questions	IP 1	10	5	15
Socratic Method of Questioning	IP 1	15	25	40
Way of the Meerkat/Lab Management/Giving Encouragement	IP 1	15	0	15
Tracking Student Progress/Ending Class	IP 1	15	5	20
Mock Teaching	IP 1	5	50	55
Annotated Sample Lesson	IP 2	25	10	35
Resources Scavenger Hunt	IP 2	5	10	15
Mock Teaching	IP 2	5	45	50
Grading Techniques and Considerations	IP 2	35	30	65
Classroom Procedures	IP 2	10	15	25
Build Up/Hand Off	IP 2	15	5	20
Diversity, Equity, Inclusion	IP 2	5	5	10
Mock Lab	IP 2	5	15	20
Academic Honesty	IP 2	5	25	30
Co-Teaching Approaches	IP 2	35	20	55
Tone and Body Language	IP 2	10	15	25
Culture Days	IP 2	15	15	30
Dealing with Classroom Scenarios	IP 3	0	20	20
Veteran Q&A Panel	IP 3	60	0	60
Working with Schools	OL	5	15	20
Curriculum Briefing/Exploration	OL	30	0	30
Curriculum Projects (x5)	OL	50	850	900
Team Check-in Meetings (x2)	OL	0	60	60
In-person Total		**410**	**375**	**785**
Online Total		**85**	**850**	**935**
Total		**495**	**1,285**	**1,780**

5. VOLUNTEER TRAINING

TEALS believes that its volunteers, while experts in computer science, require educational training before working in high school classrooms. Over the summer, new volunteers complete the TEALS training program in which they learn about and practice student-centered pedagogy, computer science pedagogical methods like tracing code memory diagrams, problem-solving with individual students, and the basics of classroom management and team teaching. The goal is to supply volunteers with a basic pedagogical framework to get them started in the classroom and to integrate feedback from the classroom teacher, school administrators, and TEALS staff throughout the year. Training also serves as a chance to build rapport and for individuals to reassess their commitment to the program.

At present, the training program consists of four components: in-person training sessions (16 hours), online training modules (3 hours), curriculum assignments (15 hours), and check-in meetings with TEALS staff (1 hour or more, as needed). The in-person sessions are generally presented as two full weekend days plus one shorter evening session. The format of training has evolved over time to balance the need to prepare volunteers, the reality of volunteers' availability and commitment, and the organization's capacity to offer training sessions around the country. TEALS staff members and experienced mentors lead in-person sessions, modeling many of the same methods volunteers are learning. The sessions are approximately 52% instruction and and 48% practice activities, building up to a series of mock-teaching and mock-lab simulations. The practical activities use real curriculum materials and student work to simulate various aspects of a computer science classroom.

In between the live sessions, volunteers complete online video-based modules and assessments, mostly focused on completing the major student assignments within the curriculum they will teach. In their teaching teams, volunteers work with their classroom teacher to complete a guided planning document called the classroom plan, which helps them establish a schedule, communication norms, and classroom policies and procedures. In addition to meeting on their own, the teaching teams meet with their TEALS regional manager at least twice during the summer to share their

progress. The check-in meetings provide TEALS staff an opportunity to ensure teams are on track and provide remediation or enrichment.

Table 4 outlines the lessons within the TEALS training curriculum. Each lesson includes at least one opportunity for practice and assessment. TEALS adjusts the training curriculum based on classroom observation data and feedback from participants both during the summer and during and after their volunteering experience.

After the school year begins, TEALS continues supporting the volunteer teams through monthly regional meetups, classroom observations and feedback, and formal and informal team check-in meetings. Veteran TEALS volunteers also serve as mentors for a subset of teaching teams (typically teams with a high proportion of new team members).

6. IMPACT AND OUTCOMES

TEALS assesses its program through a variety of measures. In this section we use data from overall TEALS programmatic metrics [3], anonymous volunteer surveys (VS), anonymous student surveys (SS), and teacher surveys (TS) where the teacher can voluntarily provide their name. The surveys are administered at the end of the school year and have a response rate of 34% for VS and 36% for TS. TEALS does not collect an exact number of students in each classroom at the end of the school year, so we cannot give a percentage response rate for SS; however, 1,668 students responded to the survey. The volunteer and teacher surveys were administered through emails from TEALS to the appropriate volunteers or teachers. The student surveys were administered through an email to the classroom team (teachers and volunteers) who then gave the appropriate URL to students to complete.

6.1 Volunteer Perspectives

Over seven years of the TEALS program, 1,500 volunteers have donated over 450,000 hours in 305 schools, working with approximately 17,000 students. In the 2014-15 school year alone, 55 teachers successfully reached handoff of the classes from their volunteers[3].

Volunteers recognize that they are making a strong impact on students. In VS, 100% of volunteer respondents indicated that they believe their service had a positive impact on students, and 87% would be likely or very likely to recommend volunteering with TEALS to friends and colleagues.

TEALS volunteers experience transformative moments during the school year that also have a positive impact on them. One volunteer shared the following:

> Walking out of class one day a student came up to me and excitedly told me an approach he took to solve one of the problems we were working on that day. Walking away from our conversation, I could not help but smile. I used to teach Computer Science but had moved into the private sector. These moments are what I had missed and what I am so grateful that TEALS has brought back into my life. Students excited about learning and proud of their accomplishments is truly a lift in spirit that cannot be matched.

Volunteers find the TEALS training program to be useful and productive. Survey data collected at the end of the volunteer training from the past two years has shown that more than 90% of respondents believed that the training was effective and that the training has made them more prepared to teach high school students. Furthermore, in the same survey, 95% of respondents reported that they learned new teaching techniques and classroom management skills directly from the training. Questioning techniques to elicit student engagement was the most-often-cited new skill learned.

The TEALS training program aims not to rapidly transform computer scientists into teachers, but rather to equip them with a framework and toolkit to be useful co-instructors in concert with classroom teachers. Through practical experience in the classroom as the school year progresses, along with feedback from the classroom teacher and TEALS staff, volunteers become more comfortable and capable teaching and interacting with students. In VS, volunteers reported a substantial increase in their perceived effectiveness as instructors, as Figure 1 shows.
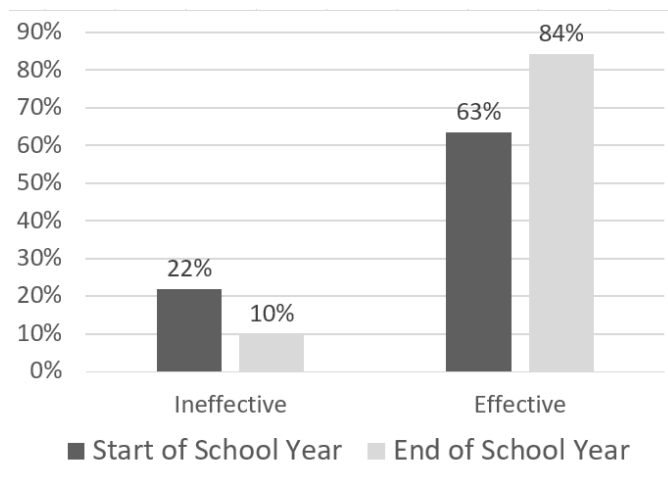

Figure 1: Volunteer Perceived Effectiveness Through the School Year

As one volunteer wrote in their end-of-year evaluation, "The time commitment IS tremendous. But I'm pretty sure that it HAS to be, because it simply takes a lot of hours to do what we're trying to do."

6.2 Student Perspectives

Students recognize the benefit in having TEALS volunteers in the classroom. In the end of year SS, 87% of students felt that having professionals in their classroom was helpful and three-quarters of the students have recommended a TEALS-specific CS course to their friends or peers. As one student put it, "the TEALS mentors were very helpful, and increased my learning in the class. Whenever I had a question about a project or activity, there was always someone with experience there to help me solve my problem."

The volunteers motivated students and generated interest in the field. Interest in pursuing computer science increased, with 48% of respondents saying they are more likely to want a career in computer science because of TEALS. As one student explained, "I never though that I'd love computer science as much as I did. The TEALS experience has changed what I want to do in the future."

Volunteers also help students develop awareness of how CS plays an important role in improving quality of life and how

programming helps to solve real-world challenges. In turn, several students volunteer to teach CS in their communities or end up using what they learn in class (e.g., build apps) to solve problems in community and school. Furthermore, 80% of students report that the TEALS course inspired them to consider or pursue additional computer science or programming activities.

TEALS volunteers are also pivotal in their students' academic success. Eighty (80) percent of students reported learning new programming skills, and 95% of the students said their programming skills improved due to the TEALS-supported course. In the 2014-15 school year, 82 schools ran a TEALS-supported AP CS A course. Seventy (70) of those schools reported their students' aggregated AP test scores, averaging 3.30 points, compared to the national AP CS A average of 3.09 points. TEALS is also beginning to see former students enter the industry and also express interest in teaching TEALS courses. Additional data collection will need to occur to understand the long-term impact of TEALS on addressing the shortfall in domestic computer science graduates.

6.3 Teacher Perspectives

Teachers also saw definite benefit to TEALS participation. On a scale of 1-6, TS respondents gave an average score of 4.8 when asked to rate the volunteers' helpfulness in learning the computer science content, and an average score of 4.3 for helpfulness in learning how to best teach that content. One teacher explained, "You can take a teacher who has pedagogical expertise and a industry employee who has subject matter expertise and together they have everything they need to run a classroom. It's a really effective way to teach students CS." This partnership is a hallmark of TEALS and helps demonstrate to new partner schools why the TEALS model is so effective.

The program has maintained its commitment to classroom handoff by helping teachers own the CS content knowledge and ability to teach CS independently. Ninety (90) percent of the teachers surveyed said that they would be ready to teach CS curriculum independently within two years. This is a significant indicator, as one of the key goals of TEALS is to help high schools build sustainable CS programs.

7. CONCLUSION

The TEALS program has succeeded in helping schools build sustainable CS programs due to its strategic investments in volunteer recruitment, screening, training, enngagement, and ongoing support. As the program—and others like it—grow, benefits accrue to a variety of stakeholders.

TEALS volunteers have a positive and lasting impact on CS education through the students they teach, the teachers they prepare, and the schools where they help establish CS programs. Schools struggle to attract CS content experts due to the shortage of talent and the difficulty in matching the financial incentives of the private sector. Programs like TEALS allow schools to tap into industry expertise, and classroom teachers who participate in the program benefit from having trained volunteers in their classroom, ensuring they have the time and access to learn how to teach CS independently in the future.

The volunteers, many of whom have a keen interest in education, benefit from working closely with a licensed classroom teacher to build their own classroom management and pedagogical skill. Volunteers also become part of a community and professional network of technical experts, all committed to advancing CS education.

Students benefit from the volunteers' content knowledge and from having the opportunity to take CS classes that might not otherwise be offered in their school. The close engagement between volunteers and students may also break down the false "antisocial engineer" stereotype sometimes portrayed by media.

Because of TEALS, tens of thousands of students have been introduced to CS and may choose to go into the field, or bring what they learned about CS to their chosen field of study. All of them will graduate high school as more informed citizens for the information age.

8. ACKNOWLEDGMENTS

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