Effective Computer Science Teacher Professional Development: Beauty and Joy of Computing 2018

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ABSTRACT

The Advanced Placement Computer Science Principles (AP CSP) course has been fully active for 2 years, garnering a large group of diverse students [2], and flaming the need for highly trained CSP teachers, especially in effective practices for diversity and equity. We have conducted summer professional development (PD) workshops from 2012-2018 which have prepared 748 teachers to teach AP CSP using the Beauty and Joy of Computing (BJC) curriculum. To improve equity and readiness for teaching, we have refined our PD by: shortening the PD from 6 weeks to 1 week; developing new, highly scaffolded pre-PD work; and modifying the in-person schedule to incorporate more pedagogy and teaching experiences, while continuing to provide in-depth, hands-on support for teachers to learn the basics of programming. The most recent revisions to our PD schedule resulted in improved post-PD survey results, with teachers from the 2018 cohort planning to adopt more of the BJC curriculum than in past years. From 2017 to 2018, planned adoption rates increased by 13%, resulting in 73% of the 2018 PD participants planning to adopt more than 60% of the BJC curriculum and 58% planning to adopt 80-100% of the BJC curriculum in their classrooms in 2018-2019. In this paper, we discuss the most recent BJC PD implementation and provide evidence of increased teacher self-efficacy in areas including fostering interest in computing for underrepresented populations.

CCS CONCEPTS

• **Social and professional topics** → **Model curricula; K-12 education;**

KEYWORDS

Computer Science Principles, Professional Development, K12 Education

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1 INTRODUCTION

In the United States, Computer Science education for K-12 is a revived concept, meaning that most teachers and schools are unequipped to handle computer science coursework and exams. In data collected on the "State of Computer Science Education", only 35% percent of secondary schools in the US teach computer science and only 22 states have K-12 computer science standards[3]. Furthermore, only 33 states have computer science teacher certification and most concerning, only 13 states have state-approved pre-service teacher preparation at institutions of higher education[3]. Meaning, the majority of teachers stepping up to the role have little to no experience in programming or computer science but are willing and passionate to learn how to teach these new topics so we can address the need for Computer Science in K-12. With computing occupations making up 58% of all projected new jobs in Science, Technology, Engineering and Mathematics fields[10], preparing in-service teachers to not only handle teaching a topic very new to them, but also giving them tools and resources to learn with their students is critical.

The National Science Foundation and the Collegeboard's Advanced Placement (AP) program worked together with educators to develop an AP Computer Science Principles (CSP) course. This rigorous, college-credit, course familiarizes high school students with the main concepts of computer science and explores how computing affects our world. By exploring computing innovations and impacts on society, students learn about how expansive computer science is as a field of study and work. The course requires students to create and write about two computational artifacts (e.g. programs) as a part of the exam. Since this course does not have a designated programming language, teachers have the flexibility to choose the programming language for their classroom [1].

The Beauty and Joy of Computing (BJC) is a curriculum endorsed by the Collegeboard for the AP CSP course and introduces teachers and students to 7 Big Ideas of computer science: creativity, abstraction, algorithms, programming, data, the internet, and global impacts, using 6 Computational Thinking Practices: connecting

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computing, programming, abstracting, analyzing problems and artifacts, communicating, and collaborating [5]. BJC was developed to appeal to a wide range of students, with the goal of providing computing education opportunities to groups that have been under-represented in computer science. In order to help prepare teachers to teach Computer Science in K-12 schools, we, along with other CSP providers, host professional development (PD) programs [4, 9].

This paper discusses how refinements to our BJC professional development workshops align with Penuel's effective PD characteristics [12], and the results of our teacher PD surveys for summers 2016-2018.

2 THE BEAUTY AND JOY OF COMPUTING: PROFESSIONAL DEVELOPMENT

As part of the national CS10K effort, we have been coordinating regional AP CSP PD workshops to help teachers prepare to offer rigorous high school computer science courses. Since most in-service high school teachers have little programming experience or computer science knowledge, the PD typically has a primary focus on programming and teaching methods to support it. Our BJC PD workshops are led by current BJC teachers who use our curriculum and who have attended both a BJC PD and a facilitator PD. Each year, new and experienced facilitators attend the facilitator PD to prepare for the upcoming BJC PDs, and learn about new updates to the BJC curriculum and national AP requirements. Typically, two experienced facilitators, accompanied with one or two new facilitators, lead a BJC PD.

3 PROFESSIONAL DEVELOPMENT DESIGN RATIONALE

Our PD is developed through a design-based implementation research (DBIR) approach of iteratively designing, testing, and refining our model with frequent feedback loops and participatory design [11]. Each year the BJC PD is reevaluated and updated to provide the most effective PD experience for teachers. We also attempt to align our PD with known effective PD practices. In recent years, we designed the PD more around professional responsibility by adding an adapted version of the Teacher Learner Observer practice [2, 6] and the Lead Learner mindset [8] to our PD schedule. Our most recent schedule, which we will go into detail in Section 4, aligns with other effective PD characteristics [9, 12].

According to Penuel et al., effective professional development should be designed to (1) focus on content, (2) promote active learning, and (3) foster coherence [12]. Two of five of Mobile CSP's recommended core features for CS PDs include focus on content knowledge and active learning [14]. Focusing on content is critical, especially during the initial PD [12], when teachers focus on developing their knowledge and comfort with the material. Promoting active learning involves hands-on activities during the PD, opening up the floor to teacher inquiry and discussion, which can lead to higher student achievement outcomes [12]. Providing teachers time to explore and understand the curriculum by planning, enacting, and revising lessons during the PD, is a concrete example of a relevant hands-on activity. A core design feature of the "Exploring CS" teacher PD is the Teacher Learner Observer (TLO) practice, where teachers role play three different roles, practicing their teacher

responsibilities, acting as students (learners), and reflecting on teaching and learning as observers [6]. Fostering coherence during PD allows time for teachers to compare their responsibilities and their district's goals to the curriculum's goals; if the goals and responsibilities align, teachers are more likely to adopt or adapt the curriculum [12].

4 BJC PROFESSIONAL DEVELOPMENT

In this section, we will describe our 2012-2015 CSP PD model and changes made to the model from 2016-2018.

4.1 2012 - 2015 BJC PDs

From 2012-2015, we held 2, 6-week PD workshops each year preparing a total of 133 high school teachers. During the 6-week PDs, teachers spent one week face-to-face, four weeks completing the BJC course online, and a final face-to-face week to prepare to teach. Price, et al. found that the 2012-2015 BJC PDs improved participants' confidence and listed several lessons learned over the years [13]. They determined one of the important aspects of high-quality PD is to address participants' needs and to adjust the PD for the participants [13]. For example, in 2012 and 2013, the six-week long BJC PD was taught by university faculty, but feedback quickly suggested that teachers would learn better from other teachers. Therefore, in 2014 and 2015, the PD was taught by experienced teachers who took the training and had taught the course. Another important takeaway from his paper was the need to model teaching and explicitly discuss pedagogy in the PD [13]. Many participants did not have a computer science background, and therefore needed to be taught both content and pedagogy. Lastly, teachers reported that experience with pair programming and team assignments helped build a community for support throughout the academic year [13].

4.2 Recent BJC PD Commonalities

In the next two sections we will discuss the 2016, 2017, and 2018 BJC PDs focusing on the major changes and the reasons behind the changes. The common elements in the face-to-face BJC PD schedule since 2016 include introductions to: (1) the BJC curriculum, (2) programming labs, (3) the programming language/environment, (4) growth mindset, (5) pair programming, (6) computing in the news, (7) course readings, and (8) The AP CSP Explore and Create Performance Tasks. Each year, teachers also complete a Create Task, where teachers create their own programs, demonstrate them to others, and answer the AP Create Task prompts based on their programs.

Each day of the 5-day PD week, teachers completed short Daily Feedback surveys asking 3 questions: (1) "What went well today," (2) "What can be improved," and (3) "Any other comments," which we review the following morning to discuss the changes for the day based on the previous day's suggestions to maximize the teacher's satisfaction and tailor to each specific group's needs. Each year, participants take a pre-PD survey, revealing their expectations and needs, and a post-PD survey, revealing their satisfaction with the PD and their expected use of the curriculum. We used online forums as a discussion platform to enable the teachers to connect before, during, and after the PD.

Table 1 compares the amount of pedagogy, programming and reflection from 2016 to 2018. Time was spent on other activities during the PD week which is not mentioned in the table.

4.2.1 2016 PD. During the 2016 PD, 104 teachers participated in 12 regional BJC PD workshops. We expanded the number of available PDs to make it more convenient for teachers to attend. We shortened the length of our PD experience from the 6-week model to a 3-week model because many teachers prior expressed that they could not commit to a 6-week PD, with many struggling to complete the online course on their own without pay. In the 2016 three-week model, the first week comprised preparatory online assignments, the second week was face-to-face, and the third week was online, comprising two assignments and office hours.

4.2.2 2017 PD. During the 2017 PD, 141 teachers participated in 7 regional BJC PD workshops. We used a 2-week model, continuing to shorten the PD to make it more feasible for more teachers. In the 2-week model, the first week comprised a smaller set of online preparatory assignments and the second week was the face-to-face week. We eliminated the third week by incorporating the assignments into the face-to-face week, and instead focused on engaging teachers in academic year online mentoring. We also lessened the amount of preparatory work, as noted in Table 1 since many teachers were unable to complete the preparatory work on their own due to time constraints and/or lack of prior knowledge.

We adjusted the 2017 BJC PD components which correlated with three of Penuel's recommendations to focus on **content**, to incorporate **active learning** into the PD, and to encourage **coherence** [12], which is networking with their peers. To improve the BJC PD content, we focused on helping teachers reflect on how students learn the BJC material by implementing the Lead Learner mindset [8]. In this mindset, teachers are encouraged to think of themselves as lead learners, helping students by showing them what an exemplary learner of CS content will do when facing problems [15]. Furthermore, we integrated more active learning into the PD in multiple ways, including reviewing student work and having teachers practice teaching labs and leading discussions. For reviewing student work, the teachers spent an hour reviewing and discussing past student submissions for the AP CSP Explore Performance Task. Teachers, assisted by BJC leaders, also led short discussions about computing in the news. During the computing in the news discussions, one teacher presents a current news article about new or interesting topics in computing and discuss the topic as a group, such as the social implications or how the topic affects them.

We also increased coherence at the PD by adding more time for networking during a teacher panel with experienced BJC teachers and from recent AP readers for the AP CSP course. These discussions helped teachers better understand the AP requirements and how the curriculum supports those requirements.

After the PD, teachers were encouraged to join online small groups facilitated by PD facilitator, and are added to our online CSP and BJC support forum that is monitored by project staff.

4.3 2018 BJC PD

When designing the 2018 PD, we kept our 2017 PD additions and incorporated more of Penuel's recommendations to continue increasing the efficacy of the BJC PD [12]. We kept the the Lead Learner mindset to help teachers think of themselves as models for their students, enabling them to learn alongside the students and demonstrate effective learning strategies [8]. We increased the number of active learning activities by incorporating an adapted version of the Teacher Learner Observer (TLO) practice [6] [2], giving teachers the chance to practice teaching, added more reflection and discussion time, having teachers complete the written components of the Create Task earlier, and adding a grading component to the PD.

To implement the TLO practice, we divided the teachers into three groups who would prepare and lead lessons (teachers) on three BJC programming labs, while other teachers would act as students (learners), and the facilitators would lead a discussion, prompting all participants to reflect on their observations (observers) of what worked from the teacher, student, and classroom perspectives [2, 6]. Initially, we followed the TLO model closely where some teacher participants should act solely as observers, but we quickly revised this directive as participant observers were upset that they could not learn the content being presented, therefore we developed Teach Learn Then Reflect (TLTR), adapted from the TLO practice. This practice integrates many of Penuel's suggestions for incorporating more active learning into the PD and helps align our PD content to the teacher's professional responsibilities, which Penuel suggests increases adoption rates [12]. We also increased coherence by adding 15 minutes of reflection and discussion time to the end of each teaching session of 60-90 minutes, where teachers take a few minutes to reflect on the activity, and then discuss what went well, what could have been improved, and how they would implement the content in their own classrooms. The remainder of this section will break down each day of the 2018 BJC PD.

Before attending the PD face-to-face week, participants are asked to complete a few short, and well-specified lab exercises from the first unit of the BJC curriculum as preparatory work. We dramatically reduced the amount of preparatory work in hopes that more participants would complete the work. Participants in prior years reported being dissatisfied with having to repeat preparatory content during the face-to-face week since other teachers did not complete it beforehand.

Day One. In the first morning, we introduce the programming environment, the BJC curriculum, and resources we will use during the remainder of the week. To set the tone for the week, we explain and discuss growth mindset. People with a "growth mindset believe that they can develop their intelligence over time" suggesting people's minds are not fixed [7]. We review the pre-PD work and then complete a programming exercise and reflection. After lunch, we complete another programming exercise and reflection, discuss some AP materials for the course, and review the expectations and schedule for the remainder of the week.

During each programming exercise, the PD leader introduces the goal of the programming activity and any new blocks or computer science concepts. Then teachers complete the programming activity in pairs to introduce them to pair programming. After completing

the exercise, the class participates in a reflection, discussing what they learned and sharing how they would teach the lab in their own classroom.

Day Two. In the second morning, one teacher presents a recent article for computing in the news. Then we complete a programming exercise in pairs. After the reflection, we divide participants into 3 groups to learn and plan to teach 3 programming labs for the Teach Learn Then Reflect (TLTR) practice. In the afternoon, one of the three groups teaches their programming activity and the PD facilitators lead a TLO reflection discussion. We close the day by exploring classroom environments and social impacts, discuss the challenges with teaching and recruiting a diverse classroom, and introduce the AP Explore Task with past students' projects as demonstrations.

A core part of the BJC focus is on providing teachers with the skill to not only teach students CS but students with diversity, such as different races, socioeconomic backgrounds, and genders. We encourage teachers to recruit students from all kinds of groups to join the AP CSP class by introducing growth mindset on day 1 and by discussing recruitment and diversity in the PD on day 2.

Day Three. In the third morning, the other two groups teach their programming labs for the TLTR, each concluded with a facilitated discussion. As a whole class, we discuss the benefits of the TLTR practice and teachers point out any pedagogy techniques they plan to bring back to their classroom. In the afternoon, we complete a programming exercise focused on the CS concept of *lists* and reflect on the activity. Then, teachers complete another programming exercise focused on the CS concepts of *algorithms* and *abstractions*, afterwards reflecting on the activity and how it completes all of the requirements for the AP Create Task. To end the day, we introduce the teachers to the Create Task, which will be their project for next day.

The CSP Create Task is a required component for the AP CSP exam. Teachers pair up with a partner of their choice and decide a project which would complete all of the requirements for the AP Create Task. The teachers work on their Create Task all of day four and part of day five. After teachers have finished programming their projects, they create a short video demo of their program, and write a report to answer the Create Task questions, both of which are things their students would have to complete for the actual exam.

Day Four. On the fourth morning, we practice a computing in the news discussion. Then, we present the AP Create Task requirements and demonstrate student work samples. The teachers spend the majority of the day developing and programming their own Create Task with their partner. At the end of the day, we have a teacher panel where our participants are able to ask any questions they have about BJC, teaching BJC, the AP exams, or anything else to the experienced PD leaders who have taught the class.

Day Five. The last day contains overviews of the remaining BJC units we did not cover in depth during the PD week. In the morning, we introduce teacher-created BJC materials, and share AP Reader teacher insights and tips. Teachers finish their Create Task and grade another team's work using the AP Create Task rubric. After lunch, we reflect on the PD week, answer any remaining questions, discuss how teachers sign up to teach an AP course, and

the teachers take the Post-PD survey, telling us how our BJC PD prepared them to teach the AP CSP course.

Table 1: Time spent on varying activities in the BJC PD schedule for 2018.

Time in hours spent on..	2016	2017	2018
<i>Pedagogy</i>	1.75	7.00	9.75
<i>Programming</i>	14.50	12.75	11.75
<i>Reflection</i>	3.50	3.75	4.50

5 METHODS

In order to evaluate and compare the effectiveness of the PD from 2016 to 2018, we collected data on (1) participant satisfaction with the PD, (2) participant's perception on their preparedness to teach the AP CSP course, and (3) the number of teachers who plan to adopt the BJC curriculum. We also collected supporting demographic information in the PD application to understand their contexts and prior CS/programming experience. The number of teachers who participated in research for the 2016, 2017 and 2018 PDs were 36, 72 and 67, respectively.

Demographic information collected on the PD application includes questions about teacher gender, school type (public/private/charter), school demographics by gender, race, and free/reduced lunch, and teacher experience level in programming (None, A Little, Moderate, and A Lot) as noted in Table 2.

Table 2: This table shows the teacher demographic for the 2016, 2017, and 2018 PD years.

Year	N	Coding Experience	Gender	School Type
2016	34	None 12%		
		A Little 53%	56% F	91% Public
		Moderate 32%	43% M	2% Private
		A Lot 6%		5% Other
2017	54	None 15%		
		A Little 44%	65% F	83% Public
		Moderate 35%	35% M	14% Private
		A Lot 6%		1% Other
2018	67	None 7%		
		A Little 43%	60% F	73% Public
		Moderate 36%	40% M	17% Private
		A Lot 15%		8% Other

On the post-PD survey, participants answered 18 five-point Likert scale questions to rate their assessment of the utility, efficiency, and organization of the PD, as well as the appropriateness of the teaching environment provided. The questions, shown in Table 3, are asked to assess how well the PD met participant needs. Teachers read the questions, such as "I can use this training to positively impact the achievement of my students" and respond with one of the following: Strongly Disagree, Disagree, Neither Disagree or Agree, Agree, or Strongly Agree.

Table 3: This table shows the average survey responses to questions intended to assess the PD.

Assessing the PD Questions	2016 Avg	2017 Avg	2018 Avg
N=	34	54	67
1. I can use this training to positively impact the achievement of my students	4.35	4.64	4.49
2. The content of the pd is relevant to my professional responsibilities	4.35	4.45	4.51
3. The facilitators helped me understand how to implement my learning	4.38	4.48	4.49
4. This pd will extend my knowledge, skills, and performances	4.44	4.44	4.58
5. This pd was tailored to meet my needs as a learner	4.23	4.18	4.21
6. The pd was supported by effective and appropriate use of technology	4.47	4.46	4.55
7. New practices were modeled and thoroughly explained	4.26	4.21	4.37
8. Sufficient time was provided for guided practice and tasks	4.15	3.83	4.13
9. The instructional techniques used facilitated my learning	4.35	4.19	4.40
10. The material used were accessible and enhanced my learning	4.50	4.25	4.51
11. The pd activities were carefully planned and well organized	4.38	4.14	4.36
12. The pd goals and objectives were clearly specified	4.38	4.24	4.37
13. The pd included a variety of learning activities relevant to the topic	4.38	4.41	4.51
14. Time was used efficiently and effectively.	4.15	3.97	4.31

Furthermore, the post-PD survey asked participants about their planned BJC curriculum adoption, and 37 questions rating their self-perceived preparedness in the following areas: **Content** (level of fluency on CS concepts), **Inquiry/Engagement** (level of fluency when fostering varying CS teaching techniques in the classroom), **Equity** (level of comfort with engaging their students to consider equity-based practices and **Preparation** (level of comfort with managing different types of situations that arise in the classroom). Teachers rated themselves on questions like “What is your level of fluency in fostering self-directed learning with your students” on a 5-point Likert scale: Don’t know, No experience, Somewhat fluent, Fluent, and Expert.

To determine if the changes to the PD from 2016 to 2018 had an affect on teacher responses, we used the Kruskal-Wallis test. Then, we further analyzed the significant differences using the Mann-Whitney U test to determine which years have differences between them.

6 RESULTS AND DISCUSSION

In the following sections, we share results about how our participants rated the BJC PD, their self-perceived ability to teach BJC, and their planned adoption rates from 2016 to 2018.

6.1 Teachers’ Assessment of the PD

To evaluate the significance of the differences between the teachers assessment of the PD from 2016 to 2018, we used the Kruskal-Wallis test and Mann-Whitney U test as appropriate. Though we did not discover many significant differences between the years for the questions, the average rating for nearly all of the teacher assessment questions was above a 4.0, meaning on average teachers agreed with the questions, as shown on Table 3. That table also shows no harm has been done by between the years. Considering the reduction of time in the 2018 schedule, this can be viewed as a positive indication of the changes made.

6.1.1 Time Spent during PD. Two of the statements found on Table 3 asked about time spent during the PD: *Sufficient time was provided for guided practice and tasks* and *Time was used efficiently and effectively*. For these statements, we expected the average to show a downward trend from 2016, a 3-week PD, to 2018, a 1-week PD because we reduced the length of the PD; however, this is not the case. Although there were no significant differences in the teachers’ assessments of the PD, we eliminated 2 weeks from the PD and our participants felt there was high-quality content and instruction, and that their time was used effectively.

6.1.2 Professional Responsibility and Teaching Techniques. Statements 2, 7, 9 and 13, found on Table 3, are related to teachers’ responsibilities and instructional teaching techniques. From 2016 to 2018, the average response to these statements increased, which corresponds with the increase in the PD time spent on pedagogy from 3.75 hours to 9.75 hours as shown in Table 3. We also believe that our explicit focus on the Lead Learner mindset and TLTR practice helped participants connect the PD to their professional responsibilities as a teacher. Teachers also got a chance to grade programming projects, which is another task these teachers will have to do regularly.

6.2 Teacher Perception on Teaching BJC

To evaluate the significance of the differences between the teachers’ perceptions on teaching BJC on post-PD survey responses for each area (Content, Inquiry/Engagement, Equity, and Preparation as described in the Methods section) from 2016 to 2018, we used the Kruskal-Wallis test and Mann-Whitney U test as appropriate. Of the 37 questions, 9 have significant p-values.

Table 4 shows the 9 questions with significant differences. Each of the questions, except the last question, have a significant difference between years 2016 and 2017, and between years 2016 and 2018. The last question on the table only has a significant difference between years 2016 and 2017. This reflects the emphasis in PD on teaching for diversity, although social justice is a topic we need to continue to improve and reiterate upon.

6.2.1 Interest and Enjoyment. During 2017 and 2018, teachers self-reported a higher comfort level of fostering enjoyment and interest

Table 4: These teacher perception question were in the Post-PD survey comparing responses from 2016, 2017 and 2018.

Teacher's Perception on Teaching CSP	2016 (avg)	2017 (avg)	2018 (avg)	<i>p</i>
<i>What is your level of fluency in fostering ... with your students</i>				
self-directed learning	3.53	3.90	3.94	0.020
interest in cs activities	3.23	3.76	3.72	0.016
concentration of cs activities	3.26	3.68	3.64	0.031
enjoyment of cs activities	3.26	3.70	3.73	0.008
<i>How well prepared do you feel to teach...</i>				
cs to female students	3.35	3.96	3.97	0.000
cs to racial or ethnic students	3.32	3.80	3.81	0.008
cs to students of low socioeconomic backgrounds	3.26	3.83	3.78	0.002
students the relevance of cs in their daily lives	3.50	3.93	3.91	0.012
<i>What is your level of fluency with integrating...into your instruction</i>				
principles of social justice	3.29	3.72	3.58	0.033

with CS activities in their classroom. One possible reason is teachers at the 2017 and 2018 PD received more insight from a student's viewpoint with the Lead Learner mindset and TLTR practice than the 2016 teachers. In addition, our group of facilitators expanded over these three years from 8 to 36 leaders, bringing varied viewpoints and growing a larger community of practice rooted by the master teachers.

Another possible reason is more reflection time allowed for teachers to discuss each activity and determine how they would integrate them into their classrooms. In Penue's paper, he concluded that teachers who have more time to think about the PD content, and ask questions to experienced teachers, would feel more prepared to teach their students [12].

6.2.2 Prepared for a diverse classroom. During 2017 and 2018, teachers self-reported a significantly higher preparedness level to teach Computer Science to female students, racial or ethnic students, and students of low socioeconomic backgrounds. We believe this is reinforced by the larger number of PD facilitators, and our improved facilitator training over the years that helped facilitators present a more consistent and research-based focus on helping diverse students succeed.

6.3 CSP Adoption Rate

Figure 1 demonstrates that many participating teachers planned to adopt or integrate some percentage of the BJC curriculum into their classroom. The 2016 data is more skewed towards the right. This may be explained by a difference in the project funding between 2016 and other years; in 2016 all participants were required to apply for crowd funding online, and this was a long and complex process that could only be completed by the most persistent and determined of teachers. Crowd-funded teachers had also publicly posted that they would teach the course, perhaps a higher bar than simply submitting an administrator support letter with their online application as required in 2017-2018. A higher percentage of teachers from the 2018 PD (73%) planned to adopt a larger amount of

the BJC curriculum (81-100%) than teachers in the 2017 PD teachers (60%). We believe this is because of our adjustment to focus the PD more on the professional preparation needed to lead, facilitate, and grade programming assignments.

Figure 1: BJC Curriculum Adoption Rate Comparison 2016, 2017 and 2018

7 CONCLUSION

To conclude, the major contribution of this work is to show that careful refinement of the BJC teacher professional development can reduce the time teachers must spend preparing in the summer while maintaining perceived levels of quality and preparedness to teach. Specifically, we recommend that CSP or introduction to Computer Science courses PDs should (1) limit preparatory work to small, well-specified tasks that do not require prior CS or programming knowledge, (2) include reflection and discussion time after each activity, (3) provide teachers with experience facilitating, grading, and learning to program, (4) facilitate discussion with experienced teachers, (5) require collaborative work, and (6) explicitly discuss strategies for supporting diverse students and classrooms. These design principles help keep the PD focused on teachers' professional responsibilities, giving teachers a chance to determine if the curriculum is a good fit for their classroom and students, which could increase adoption rates. Our results suggest that these principles have been beneficial in maintaining high-quality instruction and resulted in high teacher satisfaction and self-perceived preparedness.

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