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The Perceptions and Experiences of In-Service Teachers in a Computer Science Professional Development Program

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Abstract: This research aimed to investigate the perceptions and experiences of in-service teachers participating in a professional development (PD) program focused on computer science (CS). The main research question explored the teachers' perceptions of their experience in the CSPD program, while sub-research questions examined the challenges encountered and the program's impact on their capacities to teach CS in elementary schools. The study adopted an interpretivist paradigm and employed a qualitative research approach to understand the subjective meanings and hidden factors underlying teachers' experiences. Data collection involved observations, reflection essays, and a semi-structured focus group interview. The data analysis was guided by the community of practice elements. The findings revealed prerequisite challenges faced by the teachers, such as the need to develop self-directed learning and research skills. Additionally, the PD program was found to enhance teachers' knowledge, skills, and confidence in teaching CS. It also fostered changes in their beliefs and self-efficacy. Challenges in the pre-implementation and implementation stages were also revealed, including conflicting perspectives, limited supervisor support, and passive learning and teaching. These findings provide valuable insights that can contribute to the design of effective PD initiatives in CS education and promote sustainable education practices.

Keywords: CS teachers; PD program; experiences; challenges; K-12 CS; perceptions; in-service teachers; CS education

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1. Introduction

Computer science (CS) education is gaining global momentum. Providing CS education in K-12 offers various educational, social, and economic advantages [1]. Recognizing these benefits, many countries now require CS education for their K-12 students, ranging from mandatory to elective courses, and have integrated CS topics into other subjects [2]. However, it is well-known that computing technology is characterized by rapid and constant changes. There are two critical points worth highlighting based on the aforementioned facts: First, the education system needs to maintain an updated CS infrastructure and curriculum to ensure it can adapt to the changing nature of the field, bridging the gap between theory and practice [3]. Second, there has been a growing demand for K-12 computer science teachers in recent years [4].

Expanding CS education into K-12 has prompted several countries to advocate additional professional development (PD) programs specifically tailored for CS teachers [2,4,5]. For instance, in the United Kingdom, the Department of Education offers motivation strategies like free CS knowledge courses to engage and upskill teachers in CS education [6]. Additionally, the Computing at School program in the UK has developed a CS certification program, enabling teachers to enhance their CS teaching competence and demonstrate their ability to teach CS courses [6]. Similarly, in the United States, over 170 organizations have committed to CS training for all programs, which focuses on providing PD and continual support for K-12 CS educators [4]. Various education systems worldwide (e.g., British

Columbia and Canada) have collaborated with higher education institutions to incorporate CS education into both pre-service and in-service teacher education programs. Similarly, Poland's Ministry of National Education sponsors teacher training courses within university CS departments. Also, the Ministry of Education in Chile has collaborated with nonprofit organizations, including Fundación Telefónica and Code.org, to advance teacher training for CS education [2].

In line with the global context, the Saudi Vision 2030 introduces changes to the CS curriculum in K-12 education [7]. At present, CS education is mandatory from primary to secondary education in Saudi Arabia. The introduction of CS education in secondary schools (K10 to K12) took place in 1982, followed by its implementation in middle schools (K7 to K9) in 1997. It was just in 2019 that Saudi Arabia promoted CS education in primary schools. This has led to an increased demand for CS teachers in Saudi elementary schools. Responding to the pressing need for curriculum reform, elementary schools in Saudi Arabia, along with other countries, are recruiting teachers from diverse backgrounds, and providing them with necessary PD to meet new requirements for teaching CS.

The increasing implementation of CS education has brought about significant challenges for many countries [8]. Unsuitable teaching methods for students with varying abilities, inadequate technical expertise and skills among teachers, and a lack of development of pedagogical content knowledge to align with the new curriculum are among these challenges [8]. Moreover, when educational institutions have accepted diverse routes to becoming a K-12 CS teacher, including PD workshops, seminars, and programs, in order to best respond to the increasing quantity and quality of CS education, CS certification is not always required [9].

Hence, the need for promptly delivering comprehensive and current PD to existing CS teachers has grown more pressing. This PD is essential to address the evolving requirements of cultivating CS skills and knowledge, surmounting inherent challenges in teaching practices, adapting to the dynamic nature of the field, and attaining practical and effective teaching and learning outcomes. In other words, quality computer science education requires teachers with both sound subject and pedagogical knowledge; therefore, effective PD in CS education is critical for supporting curriculum change [8]. Despite their limited-to-no prior CS experience, one approach is for teachers to complete a K-12 CS endorsement program as part of their PD at higher education institutions [10]. By equipping teachers with the necessary knowledge and skills to teach CS, this approach contributes to the promotion of sustainable education practices. Integrating CS education in elementary schools prepares students for future careers in technology, and equips them with 21st-century skills, which are essential in a rapidly evolving world. In Saudi Arabia, there has been a focus on PD initiatives aimed at preparing teachers to effectively teach CS in elementary classrooms, and to ensure teaching capacities are earned officially, being certified through joining and completing CS endorsement programs designed to fulfill the new requirements of CS teachers. Through this PD effort, Saudi Arabia is taking significant steps towards building a strong foundation for CS education at the elementary level, ensuring that teachers are well-prepared to inspire and engage young learners in the field of CS.

Northrup et al. [10] studied teachers' perceptions of the effectiveness of a K-12 CS endorsement program. They compared the perceptions before and after actual classroom CS teaching experiences. They found that teachers expected to possess a higher level of preparation for teaching CS prior to its implementation in their classrooms. Their findings indicates that there are areas of PD that still need more research and improvement [10], and that developing effective PD has its own challenges and features in hindering or enhancing novice CS teachers' teaching capacities. Both Northrup et al. [10] and Celepkolu et al. [11] suggest additional research in order to offer valuable insights that can enhance efforts in CS teacher preparation and development.

Thus, the purpose of this research was to explore the experiences of in-service teachers in a computer science professional development (CSPD) program in Saudi Arabia, with a specific focus on understanding how these teachers perceive their PD experience in the field

of CS education at the elementary level. Hence, the overarching guiding research question of this study is as follows: "How do in-service teachers perceive their experience in the professional development program of computer science?" By investigating the perceptions and experiences of teachers involved in a CSPD program, the study aimed to contribute valuable insights that can inform the design and improvement of future PD initiatives in the field of CS education.

2. Literature Review

2.1. Effective Professional Development in CS

Teacher PD is essential for nurturing teachers' mindsets and skills that benefit students, and it is a crucial component in expanding CS education in K-12 schools [12]. While the efforts to train CS teachers are essential, it is important to consider the effectiveness of PD programs. Research suggests that acquiring appropriate pedagogical strategies, in addition to content knowledge, is a crucial factor in fostering successful teacher development [13]. A comprehensive review of 34 research studies shows that effective PD programs typically incorporate seven key characteristics: content focus, active learning methods, collaborative learning environments, models and demonstrations of effective practices, coaching and expert support, opportunities for feedback and reflection, and sustained engagement [14].

In this respect, Veen, Zwart, and Meirink [15] described two forms of PD programs: traditional and innovative. The traditional form of PD activities typically involves lectures, seminars, and conferences that are isolated from the workplace. The traditional form not only assigns passive roles to teachers, but also generates content that is disconnected from the daily problems and issues of teaching practice [15]. The most effective PD form is the innovative one. In the innovative form, participants actively construct professional knowledge, develop skills, collaborate and discuss issues related to their daily teaching practice, and consider workplace conditions. This form has the potential to improve teaching behaviors and enhance student outcomes [15]. Also, it empowers teachers to collaborate with others, observe expert teachers, review teaching situations, interact with feedback, practice teaching, lead discussions [16,17], and explore the relationship between their professional growth and the students' achievement [18]. By drawing on learner agency [19], this form enables teachers to move away from being mere attendees, taking a more active role in their own development. Menekse [20] conducted a literature review on PD programs for K-12 CS education in the USA and found that active learning is a key component in successful PD programs, as it can positively impact teaching practices and student learning.

Furthermore, the existing literature supports the notion that PD programs situated within a community of practice have been successful in facilitating teacher development [21]. These programs prove effective when participants are provided with opportunities to engage in practice and reflection, partake in discussions, and engage in peer assessment [13]. Reflection involves learning from past or present experiences and using the observed outcomes to improve future approaches. Despite the global recognition of the significance of reflective writing, a significant concern among in-service teachers in many developing countries is the limited exposure to systematic reflective models that facilitate enhanced reflexivity [22]. The literature points out the need to consider practitioners' potential misunderstandings regarding reflection by PD facilitators [23]. Therefore, Gibbs' reflective model, which is widely used for educational purposes [24], serves as a structured framework to assist teachers in their reflective writing process [22]. The purpose of reflection in the PD is to empower teachers to transition from mere experience to a deeper understanding by reflecting on the experiences they have encountered. Through the reflective process, teachers engage in critical thinking by questioning the personal significance of their experiences.

Recent findings by Northrup et al. [10] suggest that PD programs focused on CS can have a more significant impact when they prioritize enhancing teachers' confidence in teaching actual students, and providing practical classroom-ready instructional materials,

rather than solely focusing on just improving teachers' knowledge of CS concepts. Confidence enables the teacher to feel ready, while a strong grasp of the content provides a solid basis for facilitating student discussions [25]. Moreover, PD programs were found to have a significant impact on participants' self-efficacy and beliefs regarding computing and engineering, enabling them to develop a strong sense of confidence in their ability to teach these subjects effectively [26]. Other benefits of effective teacher communities include increased teacher self-efficacy and an increase in collaboration, which minimizes teacher isolation [5]. Effective CSPD achieves primary learning objectives and empowers teachers to enhance their self-efficacy, develop an asset and equity mindset, and foster a deeper interest in teaching CS [12]. Ertmer and Ottenbreit-Leftwich [27] further explained that supporting teachers in acquiring pertinent knowledge, aligning with pedagogical beliefs, and bolstering self-efficacy can stimulate transformations in their teaching practices. The intrinsic factors of self-efficacy and knowledge (i.e., technological, pedagogical, and content) are believed to empower teachers to effectively teach the CS curricula [28].

2.2. Challenges in CS Teachers' Professional Development

Some K-12 teachers are enthusiastic about CS education, but often face challenges in meeting classroom pedagogical requirements [4,25]. At the forefront of these challenges is the lack of sufficient knowledge of both CS content and pedagogy, which are essential for the effective teaching of CS [25,29]. One reason for the gap in the knowledge between teachers and the CS curriculum is due to the constant changes in the curriculum over time [30,31]. Another reason is that teaching CS is a new practice for most teachers, particularly for those who have not received a CS teaching certificate [9]. Content knowledge, pedagogical knowledge, and technology are closely related and interdependent, specifically in the field of teaching CS. Lacking either can hinder subject delivery and achieving learning objectives [4]. For example, the absence of computer devices for teaching software usage not only impedes students' ability to practically apply and create knowledge, but also inhibits teachers from utilizing content-technology-related pedagogy. This lack of technology has a negative impact on various aspects of teaching, ultimately affecting the effectiveness of CS education [4]. Teachers have identified the lack of appropriate teaching spaces, difficulty accessing technology, and undervaluing computer science as a standalone subject as major challenges when teaching CS [32].

Additional challenges in teaching CS or benefitting from PD programs result from poor personal skills. Although self-directed learning and research skills are professionally valuable [33,34], they are often cited as challenges among teachers [35]. For instance, in-service teachers struggled with research skills before participating in a PD program which was aimed at improving their ability to conduct research [36]. A lack of self-directed learning and research skills can impede teachers' abilities to learn, as both are lifelong professional development tools. For one thing, these sets of skills help teachers find helpful resources that suit personal learning needs and keep up with the pace of evolution in a particular field [30]. It also assists in conducting research, as well as searching the literature for instructional practices that have a clear link to improved student outcomes and pedagogical improvement, such as the implementation of research-based practices [33]. These skills also help in the integration of theory and practice, as teachers attempt to find answers and resources to deal with their classroom challenges. Chin et al.'s [37] study highlighted three areas of teacher needs: information technology skills, online teaching skills, and research skills. The authors emphasized the need for research skills to advance the understanding of teaching and learning processes in education. Al-Abri [38] also conducted his study with in-service teachers. The results showed that conducting research has come with its own challenges. Significantly, it is important to pay close attention to the specific needs of teachers when planning PD programs in order to help teachers overcome particular challenges.

Moreover, studies have shown that teachers face various barriers when participating in PD programs, such as balancing full-time work with part-time study, managing time

constraints, and conducting classroom investigations [39]. In-service CS teachers often find it challenging to balance teaching and PD responsibilities [31,39]. In-service teachers either work full-time while attending a program, or attend the program on certain days, making up for missed teaching days after finishing the program. Both scenarios require more work from teachers and hinder the implementation of newly gained knowledge. In one scenario, it is a highly demanding position to balance the transferring of knowledge while addressing student needs [31]. In the other scenario, teachers are busy covering many topics, thus compressing the schedule, which can negatively impact the teaching quality [31]. Teachers in Reding and Dorn's [40] study have expressed concerns regarding limited time, support, and resources when transferring newly gained knowledge into their classrooms. Suitably, in-service teachers who participated in a year-long PD program to get certified in teaching CS used various strategies, such as seeking help from their assessors, using the resources provided to them, managing their time efficiently, working during evenings and weekends, working in holidays, seeking support from their network, and requesting extensions to complete the program, while still holding a full-time teaching position [39].

Furthermore, in-service teachers reported that their CS misconception, negative feelings, students' differences in preparedness, time constraints, insufficient PD programs [11], hardware and update issues [31], scheduling, and finding enough CS resources [41] prevented them from integrating CS into classrooms. Other challenges for CS teachers include limited support at varied levels, access to technology [32], a lack of CS content and pedagogy [11,41], limited or inadequate PD programs [29,31], and isolation [4], leading to teachers who lack CS training being tasked with teaching CS curriculum [42]. This includes both teachers who lack CS content knowledge, despite a formal teaching background, and those who have taken CS courses but lack a teaching background [43]. Given the numerous challenges, training teachers to teach CS courses in K-12 schools is in high demand for overcoming teaching challenges and improving students' learning outcomes [29].

The literature shows that the shortage of CS teachers can be tackled by implementing intensive PD programs to train existing teachers from different subject areas and equip them with the skills and knowledge needed to effectively teach computing in schools [44]. Although PD plays a crucial role in enhancing teacher capacity, PD programs present challenges that could cause some poor outcomes, despite the good intentions of developing teacher capacity [5,39]. One part of these challenges is related to the providers of the program courses. For example, the program content delivery may not meet high standards due to inexperienced trainers or overly theoretical teaching methods [45]. In these theoretical teaching sessions, the passive participants simply sit and receive the latest ideas on teaching and learning from experts, without actively participating [18,46]. These types of sessions in PD programs are often too short or lack th depth to bring about substantive, sustained changes in the practice [18], and teachers may not feel personally invested in their professional growth, leading to decreased commitment [46]. This passive teaching/learning model (i.e., a deficit model) ignores the fact that teachers are sources of knowledge and play an active role in their professional development [46,47]. In fact, the key to effective PD programs is to empower teachers to not only acquire new knowledge, but also apply it wisely [46], working together with prior knowledge to fulfill PD needs and connect theory with practice [39]. One way to promote active learning and teacher agency, broaden participation, and provide long-term support and resources for potentially effective CS teaching models is by creating professional learning communities for CS teachers [4,5]. This collaborative effort brings together teachers from different schools and geographic areas, including those who may feel isolated, to ensure sustained commitment to the CS education [5]. PD programs must be based on clear and specific standards and goals that serve as the foundation for the program [20]. This will help educators adopt effective teaching methods that align with the set standards and goals. It is also critical to establish strong collaboration between local schools and higher education institutions in order to

ensure the long-term sustainability of PD and its positive impact on the quality of teaching practices [20].

3. Theoretical Framework

PD should not only include knowledge regarding content, pedagogy, and technology, but it also should entail opportunities to apply the gained knowledge into teaching practices, monitoring, reflecting, and modifying future teaching practices. This study is framed by the situated learning theory since it examines the experiences of teachers participating in CSPD. Situated learning theory asserts that learning is a social process in which knowledge is co-constructed, emphasizing its situational nature within specific contexts and its embeddedness within social and physical environments [48]. This theory explores how participants' learning within a community of practice occurs and transforms as they become integrated into that community [5]. In practice, teachers who work together towards a common goal, share experiences, speak the same language, and are open to learning from each other can be considered a community of practice [21]. The PD program for CS can be designed to align with the core principles of a community of practice. By integrating domain knowledge, fostering a sense of community, and emphasizing practical application, such a program can effectively promote collaborative CS education. In terms of the domain, the program aims to enhance the participants' knowledge and skills in CS education, providing them with the necessary expertise to effectively teach CS concepts and skills. The community aspect is fostered through collaborative interactions among teachers, creating a supportive network where they can exchange ideas, share resources, and collectively enhance their teaching practices. This collaborative community of CS teachers facilitates the sharing of experiences, challenges, and best practices, enriching the professional growth of all participating teachers.

4. Research Methodology

As discussed previously, the current trend in recruiting CS teachers for elementary education involves educators from diverse educational backgrounds. This type of recruiting requires teachers to be prepared to teach CS curriculums, as they often lack domain-related content, pedagogy-related skills, and experience [25]. Hence, it is important to understand teachers' experiences and classroom challenges in order to plan suitable PD programs that cater to their needs. It is also equally important to understand the factors that promote their learning and readiness. The present research aimed to investigate the experiences of in-service teachers in a CSPD program, addressing the main research question: How do in-service teachers perceive their experience in the professional development program of computer science? This will also be guided by the following sub-research questions:

- RQ1: How does the CSPD program help to build the teachers' capacities to teach CS in elementary school?
- RQ2: What challenges do in-service teachers encounter while participating in the CSPD program?

4.1. Research Design

The present study employed the lens of the interpretivism paradigm to develop an appropriate understanding of the in-service teacher experience for teachers participating in a CSPD program. The qualitative research approach allowed for the exploration of the subjective meanings and hidden factors of teachers' experience and how they perceive it within the context of a complex phenomenon, such as teaching and learning CS subjects. It was important to examine their experience and interpret it in depth within contextual situations consisting of individuals, materials, and social activities [49]. To achieve these research goals, a case study design was implemented to explore the phenomenon in its real context with multiple sources of data [49].

4.2. Context

In alignment with the worldwide shortage of CS-qualified teachers in an elementary school context [25,40], Saudi Arabia is facing the same challenge of shortage. Supporting this claim, the Ministry of Education in Saudi Arabia runs and offers a CSPD program for non-specialist teachers in order to prepare them to teach the computing curricula in elementary schools. The Ministry of Education does not compel elementary CS teachers to earn an official CS certificate. In fact, it enables teachers who teach other subjects in K-12 to have professional development and earn the CS teaching qualification certificate. The certificate allows the credential teaching of the local curriculum, "Digital Skills", which is provided within the computer education of the fourth, fifth, and sixth graders in Saudi elementary schools. This curriculum equips students with knowledge, practical experience, and various computing skills in areas such as productivity, internet and searching, programming, and robotics. Table 1 provides the key components of the "Digital Skills" curricula for elementary schools in Saudi Arabia.

Table 1. "Digital Skills" curricula in Saudi elementary schools.

	Grade 4	**Grade 5**	**Grade 6**
First Semester	Computer fundamentals Word processing Scratch	Computer fundamentals Word processing Scratch	3D design Excel Scratch
Second Semester	Internet Multimedia Scratch	Internet and searching skills Multimedia Scratch	Website creation Database Scratch
Third Semester	Presentation Excel Robotics	Excel Internet and social media Robotics programming	Advance document design Computer game design Sensors in Robotics

The CSPD program was divided into two levels, each lasting for 13 weeks, with a one-week break in between. These levels comprised 13 courses, covering a wide range of topics and methods related to teaching and learning computer science. During the initial stage of the courses, participants studied various subjects, including "Methods of Formative Assessment in Digital Skills", "Approaches to Digital Skills", "Computational Thinking and Programming Principles", and "Cyber Security and Research Ethics". The subsequent level of courses incorporated more advanced topics such as "Advanced Digital Applications", "Advanced Programming Skills", "Production of Digital Content", "Methods of Digital Skills Teaching", as well as a field experiences course. Table 2 outlines the structure and courses of the CSPD program.

Table 2. The CSPD program structure and courses.

Level 1 (18 Credits)	**Level 2 (18 Credits)**
Methods of Formative Assessment in Digital Skills Teaching (2 credits—online)	Advanced Digital Applications (3 credits—online)
Approaches to Digital Skills/Curricula of Digital Skills (3 credits)	Advanced Programming Skills (3 credits)
Critical issues in Digital skills teaching (3 credits)	Selected Topics in Digital Skills (3 credits—online)
Introduction to Digital Technology (2 credits—online)	Production of Digital Content (3 credits)
Digital Applications (3 credits)	Methods of Digital Skills Teaching (3 credits)
Computational Thinking and Programming Principles (3 credits)	Practicum/field experience (3 credits)
Cyber Security and Research Ethics (2 credits—online)	

The field experiences course is a central component of the CSPD program. Its aim is to equip teachers with the skills needed to teach the computing curricula in elementary

schools. The field experiences course is a structured learning opportunity, supervised by university faculty members who specialize in CS education. The participating teachers engage in two micro-teaching sessions and one macro-teaching session. The purpose of these sessions was to encourage the participating teachers to work together and to promote active and collaborative learning between teachers who share the same interests and CS teaching issues. The participating teachers took turns conducting these teaching sessions. One teacher would act as the instructor, while the others played the role of students and observers. During a teaching session, teachers took on student roles, asked questions, practiced, completed homework, collaborated, performed tasks, used computers, and engaged in other learning activities. A teacher took the instructor role and led a micro-teaching session, preparing and executing a 20 min lesson plan with one or two learning goals. The lesson plan includes all aspects of teaching, such as introduction, learning activities, and student assessments. Faculty members attended all teaching sessions as observers. After every session, faculty members and other teachers (i.e., student observers) provided oral feedback so that faculty members could supervise teachers' feedback, while other teachers could benefit from the feedback provided by faculty members. The feedback was intended to be incorporated into the following teaching practice, whether it was a micro or macro session. The macro-teaching session was similar to the micro-teaching session, but it lasted for 45 min to simulate real classroom teaching.

The PD of this research follows the [32] program structure, where the peer-instruction model follows teachers teaching teachers [5]. The CSPD program was offered in a program-level blending mode [50], as it includes eight in-person courses (24 credits) and five online synchronous courses (12 credits). The online classes took place in virtual classrooms on the university's LMS or using the ZOOM platform. The program was designed for teachers who had to work in the mornings and were available for evening classes three days a week. The program curriculum was designed to promote active learning for teachers through coaching, faculty support, team/individual assignments, micro-teaching sessions, lesson plan and teaching material analysis, self-reflection, and collaborative classroom interactions. The program also included a community of practice, dedicated to promoting collaboration and communication among teachers. In this community, a group of teachers who shared similar concerns and had a desire for sustained learning and continual peer support came together to share experiences and reflect on educational issues. By fostering a community of practice among teachers, the research promotes sustainable practices for knowledge sharing, professional growth, and continuous learning in the field of CS education.

4.3. Participants

The teachers were enrolled in the CSPD program from late August 2022 to early March 2023. For this study, seven female in-service teachers were purposefully selected, based on specific criteria. These criteria included gender, as the Saudi context is segregated, the completion of the CSPD program, and willingness to participate in the study. The teachers who participated in the study were primarily elementary school educators. However, two teachers who taught at a middle and/or high school level also took part in the study. The teachers' experience ranged from 4 to 19 years, with three teachers having experience in teaching CS, and four without CS-teaching experience. Six of the seven teachers were actively teaching while participating in the CSPD program, while one was on leave. The teachers had diverse academic backgrounds and taught various subjects in their respective schools.

It is noteworthy that none of them had specialized in CS majors; rather, they were seeking CSPD and certification. In fact, their academic backgrounds included majors in Arabic, English, Media, Islamic Studies, and Social Studies. Although they did not have a formal education in CS, the COVID-19 pandemic enabled them to incorporate technology into their teaching practice. Table 3 lists each participating teacher's current career status, educational level/stage, majors, teaching experience, and taught subjects.

Table 3. The participating teachers' teaching experience and demographic data.

Participant ID	Current Career Status	Educational Level/Stage	Major	Teaching Experiences (Years)	CS Teaching Experience		Subjects/Taught
					Years	Grade Level	
Teacher A	on leave	Elementary School	Islamic Studies	4	0	None	Math
Teacher G	working		Arabic	15	2 years	4th, 5th, 6th	Arabic, Social Studies, Science, Digital Skills
Teacher S	working		Arabic	19	One semester	4th	Arabic, Digital Skills
Teacher M	working		Media and Daawa	15	2 years	4th, 5th, 6th	Islamic Studies, Arabic, Math, Sport, Digital Skills
Teacher N	working		Social Studies and Arabic	11	0	None	All subjects for 1st and 2nd graders. All subjects (except Math and Science) for 3rd graders
Teacher L	working	Middle and High School *	English	14	0	None	English
Teacher B	working (now she is school principal)	High School *	Geographic	5	0	None	Social Studies

* They were planning to teach the elementary CS curricula upon finishing the CSPD program.

Moreover, as some PD programs are invested in major cities or regions, teachers who plan to attend them in person must make arrangements, such as informing their educational administrative office, registering and sending documents, and traveling to the programs' setting-up locations. In the present study, some participant teachers lived in one region and needed to attend the CSPD program in another region where it was offered. Teacher M, for instance, worked in a rural area, but she needed to communicate with her educational administrative office and transfer her documents to an urban region. Another teacher, teacher A, moved from the eastern to the central region, due to her particular circumstances. Those teachers who changed regions could not attend the program from the beginning. The delay was mainly due to administrative reasons.

4.4. Data Collection Methods

The data was collected by utilizing multiple qualitative methods: observations, reflection essays, and a semi-structured focus group interview. Researchers employed the triangulation of sources to improve validity and reliability, combining the strengths of multiple approaches, while compensating for their individual weaknesses [51,52].

4.4.1. Observation Field Notes

During the field experiences course, two researchers attended micro (20-min) and macro (45-min) teaching sessions for the seven participating teachers. The two researchers are professors specializing in computer education, with over 10 years of experience. The participating teachers were asked to prepare two micro lessons and one macro lesson to teach a selected topic from the "Digital Skill" elementary school curricula. The observations were designed to examine CS teaching practices. The researchers took notes that included the general descriptive observations of the lessons (e.g., "the teacher invited students to use her desktop and apply their newly taught knowledge").

4.4.2. Reflection Essay

During the field experience course of the CSPD program, 13 reflection essays were collected. A reflective form was utilized to aid teachers in reflecting on their teaching experiences. The reflective form was designed based on Gibbs' Reflective Cycle [53], which offers a structured framework with six stages for teachers to examine and learn from their experiences. The reflective form required responses to six main points: a description of the experience, feelings and thoughts about the experience, evaluations of the experience (both good and bad), analysis to make sense of the situation, a conclusion about what was learned, what could have been performed differently, and an action plan for dealing with similar situations in the future or making general changes as needed. After each micro- and macro-teaching session, the participating teachers were required to complete these reflection processes to apply their plans and changes. The cyclic nature of the process is useful, as it allows for analyzing both successful and unsuccessful aspects of the lesson, enabling teachers to plan for improvement [22].

4.4.3. A Semi-Structured Focus Group Interview

The semi-structured focus group interview was conducted to gather insights about teachers' experience in the CSPD program. Six of the participating teachers consented to share their experiences. The interview guide was developed after reviewing the existing literature, aiming to address research questions about the challenges the participants faced while participating in the program and the factors that contributed to the development of their teaching capacities, within the context of elementary school CS education. The primary questions that guided the focus group interview were as follows: (1) Describe your experiences in the CSPD program. (2) What factors have an impact on your success in the program? What is the impact on your professional practices? (3) What are the challenges you encountered while participating in the CSPD program?

The interview, which lasted for two hours and six minutes, was conducted via a synchronous ZOOM session by one of the researchers and recorded for reference. To ensure effective communication and the detailed expression of their views, the interview was conducted in the participants' native language. The focus group interview facilitated dynamic discussions, diverse perspectives, and idea exchanges, resulting in a deeper understanding of the studied phenomenon [51].

4.5. Data Analysis

The collected data was analyzed by two authors using reflexive thematic analysis, which involved a careful review of transcripts and content, coding, generating meanings (initial themes), developing and reviewing themes, refining and naming themes, and writing up the analysis [54]. Therefore, themes in the present study were not predetermined, but rather emerged from the collected data. The two authors first reviewed the collected data, including the ZOOM focus group interview, reflective forms, and observation field notes to gain familiarity. After that, they transcribed and reviewed the transcript multiple times to ensure accuracy. The next step involved each author independently applying reflexive thematic analysis to the entire dataset. The authors then held several meetings to review the identified themes and coded data. The meetings resulted in an agreement on the final main themes and sub-themes. This process involved multiple cycles of separating, merging, and adding sub-themes, while also reviewing and modifying terminology to ensure that the coded data accurately reflected the agreed-upon themes and sub-themes. Any disagreements were resolved through discussions. The last step was writing up the analysis. During the writing process, Arabic data, such as quotations or participant perspectives, were translated into English as needed. Throughout the listing up of the analysis steps, we went back and forth between the different steps as we progressed in our analysis and writing. It is worth noting that the focus group interview was essential in gaining a deep understanding of the teachers' perceptions and experiences. The resulting data was then cross-verified and validated through reflective forms and observation field notes, allowing for a more thorough exploration of the identified elements.

4.6. Ethical Considerations

Ethical research approval was granted from the Ethics of Human and Social Research Committee of King Saud University (KSU) to conduct the present study (KSU-HE-23-771). Informed consent was obtained from all the participating teachers before taking part in this study. The participating teachers were also informed of their anonymity and their right to withdraw from the study at any time without giving a reason.

5. Findings and Discussion

5.1. Research Question 1: How Does the CS Professional Development Program Help to Build Teachers' Capacities to Teach CS in Elementary School?

The CSPD program yielded three main themes that encompassed the participants' experiences, enhancing their ability to teach CS at the elementary school level. These themes include program components, effective pedagogy, and the changes observed in beliefs, self-efficacy, and practices. In terms of program components, it was evident that the PD program played a crucial role in equipping teachers with the necessary knowledge and skills required for effective CS instruction. The positive experience of effective pedagogy employed by the program faculty underscores the importance of implementing appropriate instructional strategies and approaches to effectively engage teachers and facilitate their learning in CS. Moreover, the study highlighted the notable changes in teachers' knowledge, beliefs, and self-efficacy as a result of their participation in the PD program. These changes signify the growth and development of teachers' confidence, attitudes, and understanding in teaching CS.

5.1.1. CSPD Program Components

The participants emphasized that the CSPD program components had helped them to be aware of CS topics and skills, improving their digital literacy. For example, teacher G said "I became aware of something called digital. I always heard about digital skills, the digital world, but I was not aware of what digital means . . . but after this CSPD program, I felt aware and became aware of the digital world and its importance". The participating teachers acknowledged the positive impact of two key components of the program: subject content including the development of programming skills tailored for elementary education, and micro- and macro-teaching.

Subject content. The findings show that the program's curriculum was designed to meet the specific needs of CS teachers in developing their knowledge across various CS topics. It offered comprehensive courses covering important areas, such as programming, content analysis, cybersecurity, and multimedia creation, specifically focusing on video and audio file production. The participants indicated that the courses equipped them with the knowledge and expertise necessary to effectively integrate these subjects into their classrooms. During the focus group interview, teacher M pointed to the impact of the content analysis component in empowering teachers to understand the curriculum; she said "It was really wonderful. I have been wishing for a long time to learn how to analyze". She also emphasized the significance of cybersecurity in the digital age, equipping teachers with the skills to educate students about online safety and privacy. She said "We were asked to design a video about cybersecurity to raise awareness for children. This is also a very beautiful experience". Moreover, the program provided training in multimedia creation, particularly in designing video scenes and creating engaging multimedia materials. This equipped teachers with the ability to use multimedia effectively in their instruction, enhancing student engagement and learning outcomes.

Furthermore, the findings confirm that the formative assessments course is a crucial component within the CSPD program. One participating teacher, for example, highlighted that formative assessment involved the implementation of weekly assessments, carefully designed to gauge teachers' understanding and progress in acquiring new knowledge and skills in CS pedagogy. Teacher N said that she learned the importance of formative assessment and she emphasized "I benefited from the courses, [meaning] the formative assessment course . . . We have recently begun utilizing worksheets in a more structured way. We now have a better understanding of how to effectively use them. We understand what content should be included in the worksheets, when it is appropriate to use them, and how to assess learning outcomes". By regularly assessing their comprehension and performance, the formative assessments provided valuable feedback and insights to both the teachers and program facilitators, enabling them to identify areas of strength and areas that required further support or clarification.

Significantly, the findings confirm that programming is an essential component of PD for elementary CS teachers. Several teachers stated that they had no knowledge about programming and that the programming courses, Scratch and Python, had a positive impact on their PD. For instance, teacher N reflected on the programming courses and their impact on her learning experience and personal growth highlights the significant benefits of the CSPD program, as she said "Python and Scratch as well. We started learning them from the beginning . . . The last lessons included Scratch. If Dr. *** had not explained to us, I would have not known. How would I have conveyed the information to them [students]? I benefited. It has even affected my personality. I can speak with confidence about the information I have". Additionally, most of the participating teachers confirmed that the programming courses were very helpful to build their knowledge of the elementary programming curriculum, as well as the self-confidence needed to teach CS in elementary schools. For example, teacher G, who has been teaching CS for two years before enrolling in the PD program, said "although I have experience with computers and have taken courses on digital applications, my knowledge was mainly limited to MS Office programs. I was not equipped to teach computer curricula". She added, "There are things that I did not

understand in the subject, and I have to go back to references . . . especially programming. I was suffering, but when I joined the [PD] program I was completely developed. I can say 95% without exaggeration". This finding aligns with the literature that emphasizes the crucial requirement for K-12 CS teachers in PD programs to possess programming skills [4].

Micro- and Macro-teaching. Micro- and macro-teaching were considered by the participants as a key component of a successful PD. During the last course (field experiences) of the program, the participating teachers were enabled to deliver short sessions to peer groups. In the subsequent focus group interview, most of the teachers emphasized the importance and positive impact of micro- and macro-teaching on their professional growth. For example, teacher N explained the overall advantage of the sessions for her teaching and learning experience: "At the beginning of the semester, we had anticipated that one [micro-teaching] session would be sufficient. However, we ended up realizing the benefits of having multiple sessions, and we loved it". Fostering active learning and engaging the teachers as learners in a supportive and collaborative environment were some elements that highlighted the benefits of the micro-teaching sessions. The teachers were able to benefit from each other's teaching sessions, which in turn helped them develop their knowledge, skills, and pedagogy in teaching computing. While experiencing the CS curriculum as a learner, one of the teachers, S, criticized her colleague for not understanding the meanings of computing terminology. She suggested that the teacher should differentiate between a browser, search engine, and website and be mindful while framing questions to encourage students participation. Another teacher, M, suggested that her colleague should arrange her PowerPoint slides in a way that would not confuse the students. During the focus group interview, teacher M expressed the learning benefits of micro-teaching saying, "As a course [field experiences], I gained benefits from it, I would say 95%, including your guidance [faculty members], experiences of colleagues, and my exposure to the diverse teaching styles and methods. I considered your criticism [faculty members] of my colleagues as it was for me to learn from and improve not only in the subject of Digital Skills but also in the other subjects I teach". Teacher N specified the advantages of exchanging and developing experiences with colleagues: "I attended four micro-teaching sessions for my colleagues each week. These sessions helped to strengthen my teaching skills. . . During each session, I learned from my colleague's mistakes and benefited from their new ideas. . . I enjoyed adding new stuff to my experiences. . . we benefited from it [micro-teaching]". In addition, teachers S and N emphasized the positive impact of feedback on information retention, "in micro-teaching, we attended to each other and listened to the feedback, this has helped in the information application, verification, and retention". Teachers S, N, and B highlighted the value of these benefits in their reflection essays too.

These findings are consistent with research that shows that micro lessons should be an integral part of teacher education, as they help to develop student teachers in various ways, including enhancing their professional skills [55]. In addition, grouping teachers together while working on CS teaching and learning activities, sharing areas of interest, collaborating with each other, discussing issues related to their curricula, and collating and curating a body of knowledge around CS practices was recommended in the literature to maximize the benefits of PD [56]. Learning CS concepts and teaching strategies together provided a valuable opportunity for teachers as they not only practiced new concepts, but also experienced the struggle of learning new knowledge in a supportive environment [57].

Furthermore, the teachers pointed out the importance of learning with and from each other, "what helped us were our instructors and colleagues. I mean, our colleagues in the same program provided motivation and moral support. . . I took advantage of every teacher who made a mistake", and "enriching discussions with colleagues broadened my perspective and expanded my learning opportunities", teachers N and L said, respectively. These settings would assist teachers in building relationships, communicating, and sharing field stories and problems. These findings align with the existing literature that emphasize integrating micro-teaching into PD programs in order to develop collaboration skills [55] and learn from each others' developing practices [58].

5.1.2. CSPD Effective Pedagogy

The participants' experiences were positively influenced by effective pedagogy implemented in the PD courses, which encompassed active learning and reflection essays. The participating teachers expressed satisfaction with their performance in courses designed to promote active learning and collaborative participation, which is in line with the findings of several other studies, including those by Veen, Zwart, and Meirink [15], Menekse [20], and Darling-Hammond, Hyler, and Gardner [14]. In addition, these findings align with the existing literature, which suggests that reflective tools help student teachers [55] and university-level CS teachers in self-education and improvement [59].

Active learning. The current study demonstrates that active and collaborative learning are vital components of effective PD programs. The participating teachers indicated that these active-teaching methods enhance their learning and teaching. For example, teacher S stated "I have noticed significant changes in my teaching approach since the first semester". The findings emphasized the importance of teachers sharing their experiences and participating in discussions and brainstorming sessions. Teacher L highlighted the positive impact of these discussions, noting that they broadened their perspective on learning by exposing them to a variety of colleagues' experiences. She said "enrichments in discussions; when colleagues talk about their experiences, they open my mind to other things or ways of learning". In this regard, teacher N highlighted the effectiveness of discussions, questioning, and feedback in promoting a clear and deep understanding of the course content, as she said "the discussion we had made a significant impact on us. You know, questions that led to more questions forced us to gain a deeper understanding. This is when we learned about formative assessment, including what, when, how, and why to use it". The CSPD program created a supportive environment for teachers to explore new teaching methods and expand their educational knowledge.

Moreover, discussions were highly appreciated in online courses. Teacher L shared her positive experience in one of the online courses: "Even though. . . the dialogues, experience exchanges, assignments, and discussions have been highly beneficial". Effective online learning and teaching require a pedagogical approach that heavily relies on active and social participation. In alignment with Carrillo and Flores's [60] study, all participating teachers reported high satisfaction with an online class that incorporated active learning, regular discussions, group participation, and constructive feedback. Describing her experience in one of the online courses, teacher S remarked "We completed the formative assessment course and gained a comprehensive understanding of the material, despite it being theoretical and online. The course was highly informative and advantageous". However, teacher L expressed her preference for face-to-face classes: ". . . I do not feel fully present when listening remotely. In-person attendance is different for me. Face-to-face interactions provide a higher exchange of experiences. Despite the convenience of online courses, in-person courses offer better academic benefits". This finding is consistent with the literature, indicating that students tend to be sensitive to the implementation of online courses and often perceive them as less advantageous compared to face-to-face classes [61]. When designing online classes for teacher education, it is important to consider the interactions between learners, instructors, technology, designs, context, pedagogies, instructional interventions, content, personal experiences, goals, activities, and feedback, leading to achieving planned goals.

Furthermore, the feedback provided by program faculty to the participants fostered constructive discussions and reflective practices, leading to improvements in their teaching methods. In her reflection essay, teacher S expressed her gratitude for receiving feedback: "Preparing the lesson in advance for my supervisor's feedback [faculty member] and revising it before teaching made a great contribution". Teacher G stated that teaching methods used by the program faculty were very effective in constructing deep understanding of the content, recalling new and previous knowledge, and enhancing teaching practices. She emphasized the impact of effective feedback on their teaching practices development: "Dr.*** used to give us these tasks, and when we solved them, she discussed our solution

and did not give us corrections. For example, I had a misconception. She did not say: You are wrong, instead she let me conclude, and this is a very beautiful thing. She made me think, brainstorm and get to the correct conclusion". This finding aligns with the research conducted by Rodriguez et al. [16], indicating that a critical factor for effective PD was the facilitation of active participation among teachers in their own professional development.

Reflection Essays. The teachers participating in a teaching session were required to submit a reflection essay on their teaching experience. The findings show that reflection on teaching was new for some participants. Teacher S shared her perspective in the focus group interview saying "The reflection essay form was a new experience. It was my first time reflecting on my teaching". Despite being a new experience, the incorporation of Gibbs' Reflective Cycle into the reflection essays allowed the participating teachers to reflect on their teaching practice. In fact, all teachers have submitted their reflection essays, which include a description of their teaching experience, their feelings about it, an evaluation of the experience, an analysis of the situation, areas of improvement, and a plan for future teaching.

Furthermore, the findings indicated that reflection essays provide teachers with numerous benefits, such as encouraging critical thinking and facilitating the development of new insights and appreciations [31]. For example, teachers were able to recognize the important role of reflection in improving the practice, thus enhancing students' comprehension. Describing her reflective process during the interview, teacher N emphasized this role, saying "I can summarize this point with this point. I can put this here. I can place this video before this point so that they [students] understand many things. Reflection is really wonderful". The reflection essays also allowed the participating teachers to highlight the importance of professional development. Teacher B, who has not taught elementary school students, gained an understanding regarding the relationship between knowledge and practice, as she expressed her desire for improvement in her reflection essay: "Because it was the first micro-teaching lesson, in which I dealt with young students, I realized that relying solely on knowledge of teaching methods was insufficient. I need to improve my teaching skills to teach elementary school students. . . I need to improve my performance through practicing, utilizing faculty feedback, exchanging colleagues' experiences, using age and content-appropriate teaching strategies, and self-learning". Teacher G also reflected on her continuous need for professional development: "I still have a constant desire for self-improvement and am still dissatisfied with what I do".

In addition, the benefit of reflection in enhancing future teaching practices and lesson plans was acknowledged. During the reflection process, the participating teachers were able to recognize gaps in their teaching practices and plan for future improvements. Teacher B, for instance, reflected on her lesson by identifying a weakness and developing a future plan: "I felt that my style was devoid of vitality and did not suit the age group. I adopted the traditional way of teaching rather than engaging them, and that was not good. . . it would be better if students applied practical steps to insert pictures from files or the internet. This method will enhance information retention. I can see that a computing lesson should include both conceptual and application aspects, with an emphasis on the application side". Analyzing teachings practice was also raised in the focus group interview. Teacher S highlighted this benefit, saying "while I am writing the reflection, I would say next time I would not do this, I would not use this approach, I would use worksheets instead". Moreover, reflection essays were useful tools for teachers to focus on effective teaching strategies. It helps them to evaluate their teaching experiences and identify strengths. In her reflection essay, teacher M mentioned that she employed effective strategies: "the link between pictures and concepts was appropriate and effective for the students of their age group. Pictures draw students' attention more". Teacher G also pointed out her appreciation for utilizing feedback with students since it helped them with learning: "Feedback is of great importance in fixing errors and confirming correct information". Reflective practices are frequently discussed in terms of their benefits for students, but the advantages they offer to educators are often overlooked in the literature [23]. This

study has filled the gap and revealed significant advantages of reflective practices for teachers. These advantages include recognizing the importance of reflection for students' understanding, acknowledging the significance of professional growth, and enhancing future teaching practices, while increasing self-awareness by identifying weaknesses and focusing on effective teaching strategies.

5.1.3. Changes in CS Self-Efficacy, Beliefs, and Practices

The participating teachers reported significant shifts in their beliefs and self-efficacy, as well as their learning and teaching practices. This finding supports the research conducted by McGill et al. [12], highlighting the effectiveness of CSPD programs in empowering teachers to enhance their self-efficacy. In addition, the findings of this study align with Rich, Mason, and O'Leary's [26] research, confirming that professional development programs have a significant impact on participants' beliefs, enabling them to develop a strong sense of confidence in their ability to teach effectively.

Learning and teaching self-efficacy and beliefs. The participating teachers indicated shifts in their beliefs and self-efficacy regarding teaching CS curricula after completing the CSPD program, such as improved resource utilization and expanded understanding of CS concepts. The findings indicated that participating teachers acquired the skill of utilizing the available resources effectively. For instance, teacher S described how the CSPD program transformed her belief that a lack of desktop computers could hinder teaching computer curriculum. Through the program's positive teaching sessions involving observation, practice, and reflection, she adopted a new perspective. She now believes that teachers can leverage the resources at hand to accomplish their instructional objectives. She expressed "Really, I do not need a computer lab to teach. It is true that it is very important, but I can harness other tools to serve the curriculum in an easy and pleasing way to the students". She shared an intriguing example regarding a challenge her colleague encountered while attempting to teach students about keyboard components without access to a computer lab or a physical keyboard. She went on to recall "I remember a lesson when Dr. *** advised my colleague to provide her students with a printed keyboard on paper!" These findings confirmed that courses have been instrumental in empowering teachers to develop the essential knowledge and self-confidence required for teaching CS in elementary schools. This aligns with the findings of other studies [25,62], which also showed that the CSPD enabled teachers to feel at ease, while acquiring new knowledge, mastering new skills, and gaining confidence and comfort in teaching computer science.

Moreover, the results demonstrated how the participating teachers broadened their comprehension of computer-related concepts. For example, teachers G and M developed a new scheme of computing concepts. They expanded not only their understanding of computing concepts, but also their self-efficacy of learning and teaching computing concepts in English as they felt confident and proud. One of the participating teachers reflected on her newly acquired understanding of computer terminology, particularly referred to as digital literacy and computer literacy. This finding was highlighted in the focus group interview. Teacher G expressed "I became aware that there is computer terminology... It is digital literacy and computer literacy. There are certain terms. Every word I say has a meaning that is not the same as the first ... there are special terms that we can say in English and in Arabic". Teacher M added that "I have come to realize that there are terms that are specific to CS". During the PD program, the participating teachers have always been encouraged to use computer terminology accurately. For example, during a micro-teaching lesson, teacher B mistakenly referred to two different MS Word documents as pictures, which may have caused confusion among students. A faculty member stressed the significance of differentiating between CS terms and correcting any overlapping between them. In another scenario, teacher G referred to "folders in Google Drive" as simply the "computing cloud", and used the term "browser" interchangeably with the term "search engine". Faculty members helped her to differentiate between the terms. Teacher S also needed to use specified computer concepts to define questions in

order to remove any ambiguity and motivate students to answer them. Mixing up terms can be problematic for students in the early stages of learning computer terminology as it can lead to misunderstandings. Accurate comprehension of CS concepts is vital for improved performance and critical thinking [63].

Learning and teaching practices. The participating teachers indicated shifts in their learning and teaching practices of CS curricula after completing the CSPD program. In a specific sense, the results suggested that participating teachers emphasized the importance of creating a more active learning and enjoyable CS learning and teaching experience. As an illustration, teacher G highlighted how the CSPD program assisted her in cultivating the belief in fostering enjoyable learning and teaching for better understanding. She described a shift in her teaching approach, where she no longer concentrated solely on completing the scheduled content. Instead, her focus shifted towards understanding her students' needs and helping them actively build knowledge, while promoting a sense of enjoyment in learning: "Now that I've grasped the subject matter, my concern lies not just in delivering the lesson and wrapping it up, as I did in the past. Instead, my priorities have shifted towards caring for my students, their comprehension, and their enjoyment. . . My beliefs have transformed from being book-centric to being student-centric". In her reflection essay, teacher G emphasized this transformation: "I did not previously realize the importance of student-centered learning activities, with the teacher directing, organizing, and constantly providing feedback". Teacher M shared the same belief of enjoyable learning, stating "I believe that learning through play is suitable. We need to emphasize application. Students should actively apply and find enjoyment in the process". These results align with other studies (e.g, [17,28]) in that changes in knowledge, beliefs, and self-efficacy can help teachers improve their teaching practices, which in turn can enhance student learning. The present study also yielded similar findings to those of other studies [28,64] which revealed that teachers who took part in the PD program reported an increase in their confidence level to achieve the instructional objectives of CS curricula.

Moreover, the participating teachers reflected on the importance of specific teaching methods for teaching CS. Teacher S pointed to collaboration, game-based learning, and problem-based learning, as she said "Promoting collaborative work and active learning among students serves the educational lesson goals, enhances students' understanding, and gives the lesson diversity and vitality", and "game-based learning, problem based learning are essential [teaching methods] for CS". Teacher B held the same belief of enjoyable learning. Reflecting on her teaching experience, she stated "I have noticed that my students often engage in activities that involve playing". It was always highlighted by the faculty members that the learning objectives of teaching must be aligned with the education goals of Saudi Vision 2030, which encompasses the transfer of knowledge, the utilization of technology, and the localization of expertise. The faculty members further elaborated that these learning goals cannot be accomplished without incorporating active learning in a regulated manner, considering other aspects within the learning situation such as students, their backgrounds, skills, environments, and so on. This will contribute to achieving the intended objectives effectively. In micro- and macro-teaching sessions, the participating teachers applied active learning activities, such as peer evaluation, collaborative learning, hands-on activities, and application of knowledge. They also provided constructive criticism to each other for not involving students or not adopting a student-centered approach. These findings align with the existing literature that points to an effective PD, enabling teachers to engage in peer assessment [13]. Teachers S, M, and N criticized colleagues who did not use active learning and praised those who did. Many PD providers expressed a strong interest in incorporating learner-centered pedagogy, such as problem-based learning (PBL) into CS classrooms, which emphasizes the application of computational tools to solve authentic real-world problems [5].

Additionally, the participating teachers N and S illustrate how their teaching practices have evolved as they started to consider the relationship between learning objectives and assessment. Teacher N explained "In the past, we would simply add questions to

a worksheet without a clear connection to a learning goal. Now, I understand that the questions in the worksheet must be linked to a specific learning objective, rather than being random. We should determine the learning goal, including what we want to measure, when, and how". Teacher S remarked on the criteria for selecting appropriate assessment tools: "The curriculum has provided guidance on how to use assessment tools and methods to achieve educational goals. The key is to avoid using it randomly and to ensure it enhances the lesson rather than dominating it. It also means what is appropriate for different ages, needs, and learning styles, whether students are working individually or collaboratively. Before the PD program, this valuable information was not available". This finding shows that CSPD plays a crucial role in enhancing teachers' knowledge and skills related to assessment methods.

5.2. Research Question 2: What Challenges Do In-Service Teachers Encounter While Participating in the CS Professional Development Program?

The CS-participating teachers have been confronting a variety of challenges while participating in the CSPD program. The findings reveal challenges that teachers faced during their teaching practice in schools and during joining the CSPD program, which is presented in the following sections as prerequisite skills challenges, implementation challenges, and teacher-based challenges.

5.2.1. Prerequisite Skills Challenges

The findings provided evidence suggesting the existence of challenges associated with prerequisite skills required for enrollment in the CSPD program. These prerequisite skills include self-directed learning skills and research skills. The findings align with the existing literature that highlights the significance of self-directed learning skills and research skills necessary for successful enrollment in PD programs [65,66].

Self-directed learning skills challenge. The participating teachers were required to demonstrate self-directed learning skills that are essential for personal and professional growth [34]. Certain faculty members tasked the participating teachers with small projects to complete on their own. Other members requested that teachers teach certain aspects of their lectures to aid in understanding the assigned topics. The teachers were able to recognize self-directed learning benefits. Teacher S explained how self-learning broadened her understanding of the curriculum: "By practicing self-learning and research, I familiarized myself with the curriculum and developed my skills". However, some teachers were new to self-directed learning and cited it as their first experience: "I had heard of self-education before, but I had never practiced it until the PD program", Teacher S continued, and Teacher M agreed.

The participating teachers were not satisfied about their outcomes and their ability to learn independently. They stated that these requirements were extremely daunting and presented significant challenges that they needed to tackle, and they constantly doubted whether they had completed the tasks accurately. Teacher N, for example, stated "I find it overwhelming to assign parts of lectures to students for self-learning and teaching". This finding pointed to the need for feedback, while being encouraged to be self-learners. Thus, researchers have recommended incorporating explicit components of self-directed learning into teacher education programs [65].

Lacking scientific research skills. Regarding the participating teachers' proficiency in conducting research, it appears that many of them entered the PD program without possessing the essential fundamental skills. In fact, the majority of them have openly expressed facing challenges due to their lack of research skills: "scientific research has specific methods. I used to tell my students to do research without giving them the basics of how to conduct scientific research. It was difficult for me and a challenge", teacher S said. The participating teachers have specified difficulty in understanding basic scientific research methods. Teacher N articulated that "I did not have extensive knowledge of scientific methods, techniques, and research". They also reported difficulty in distinguishing between

a report and scientific research, as teacher M stated "I did not even know the difference between research papers and report papers". Teachers can enhance their professional curiosity and literacy, explore student behaviors, and improve teaching by developing research skills and participating in teaching missions [66].

As part of the program courses, teachers were required to submit scientific papers. However, the participating teachers were not familiar with the essential components and principles of constructing a scientific paper. Accordingly, the participating teachers sought help and support to complete their scientific paper assignments. They asked faculty members for websites and resources, searched the internet and social media for research specialists, and unintentionally plagiarized from other papers: teachers S and N described "because I did not have extensive knowledge of scientific methods, techniques, and research, most of my submitted work was copy-paste", and, "I asked Mrs. *** for resources to learn about scientific research, and she sent me a couple of websites. However, we could not benefit from the websites because they required registration with students' ID numbers, which we did not have. . . I searched the internet and telegram for help, asking if anyone could do a search for me. I could not do the research myself. I must rely on copying and pasting. It is hard, it is hard".

The teachers justified their lack of skills by blaming the time gap between their graduation and current requirements. Teacher N stated that scientific research was not a part of her bachelor's degree program as it was not offered at the time of her graduation: "It has been almost 20 years since I graduated. We did not have any courses that focused on teaching methods or scientific research. The current graduating students are better than us. They are knowledgeable in writing research papers, including proper structure in the introduction, body, and conclusion, as well as creating a reference list. We do not possess this particular background". Teacher N also mentioned that faculty members expected her to write scientific papers without teaching her the necessary skills. She argued that she came to learn from faculty members' experience, not to feel overwhelmed and incompetent: "I was interested in gaining an understanding of scientific research. I do not want a faculty member to assign me a research paper without showing me the right way of doing it. I wish we had a course or faculty member dedicated to teaching research skills before assigning tasks".

Regarding teacher N's claim, it was pointed out that the teachers-as-researchers approach is essential for teaching research [33,67]. Heikkilä and colleagues [35] explained that, through engaging with research and understanding interpretations, teachers can construct a strong knowledge foundation and incorporate findings into their school practices. Teachers can also flexibly transmit ideas and concepts by evaluating their personal ideologies and experiences [68]. The lack of these skills was an obstacle that hindered teachers from achieving course goals. Teacher N explained that conducting research remains challenging, even after completing the program due to a lack of necessary skills: "It is an obstacle because I have not learned it". She wanted to acquire scientific research skills and use them to assist her students. She added that "I cannot teach research because I lack the necessary research knowledge and skills". This finding indicates that it is necessary to update PD programs to include scientific research courses. Teachers need to teach and conduct research for professional development [66]. Conducting scientific research and imparting knowledge through teaching are crucial aspects that cannot be overlooked. Research abilities are perceived as a means to connect theoretical knowledge with practical applications within the work of educators [35].

5.2.2. Pre-Implementation Challenges

This section focuses on the challenges related to the pre-implementation of the CSPD program. These challenges involve aspects such as relocating teachers to the university's city, inadequate school technology, and conflicting perceptions.

Relocating teachers to the university's city. As the CSPD program was offered by multiple universities in different main cities, teachers must be registered as students in

a university system to attend the program. Following the program in a different region requires sending registration documents from one region to another. Sending and receiving registration documents among and between universities and the Ministry of Education took a long time. This delay undesirably affected teachers' studies. For example, teacher A stated that she missed multiple lectures and was not able to submit assignments on time when she moved from the eastern to the central region: "I began my registration process in the Eastern Province and received acceptance immediately. Upon starting my university studies, I had to transfer to a different institution. It was challenging as it took a long time, causing me to miss many classes and affect my assignment or project submissions". Teacher M faced the same challenge despite her signed pledge to pay attention to her job as an in-service teacher, who would travel for two hours each day when she had the program courses. The university already announced her admission. However, since she intended to attend the program which was outside of her educational administrative office area, she was unable to attend the beginning of the semester due to delay of transferring documents: "I was able to join the program easily, either through my administration or the university. However, my acceptance was delayed because I had to transfer from one region to another. I also had to pledge to conditions, for example, joining the program would not affect my work".

On the other side, teachers living and studying in the same city where the program was set up did not face these challenges. Instead, their admission and starting day went smoothly. Teacher S stated the smooth process of selecting the university and the program: "I registered last year to study for a diploma, specifying my preferred university and specialization". For fruitful and collective benefits for teachers, universities and educational administrative offices need to create smooth communication channels to facilitate teacher transfer from one school to another, mainly if PD programs apply the same admission conditions. Alamri [69] pointed out the crucial role of effective communication between education systems in the provision and success of PD programs.

Insufficient school technology. The participating teachers faced the challenge of the inadequate availability of school technology when teaching the computing curriculum. Both hardware and software facilities are crucial for supporting students in their acquisition of computing knowledge and skills [4]. However, students in these classrooms lacked access to desktop computers. This technology shortfall posed a significant obstacle, particularly for teacher G, who had two years of experience teaching computing, the "Digital Skills" curricula, before enrolling in the CSPD program.

Teacher G elaborated on her experience teaching CS, and how the limited technology resources in her school affected her students' learning. She noted that the classroom projectors frequently experienced technical issues, and the school administration was not always prompt in addressing maintenance needs. She explained how she felt compelled to instruct students in basic computer skills, due to the absence of computer devices, saying "Honestly, I had to guide students step-by-step, instructing them on tasks like 'Do this, do that, look at the keyboard, find the enter key, and so on.' Teaching these fundamental computer skills was a significant challenge for my students, as these skills formed the foundation for more advanced lessons and were interrelated across various subjects. Students who lacked these basic skills often struggled and were unable to overcome these difficulties. To assist my less proficient students, I permitted them to use my desktop computer during class since they did not have access to their own devices". Reflecting on one of their lessons, teachers M and G attempted to address these issues by assigning a substantial amount of homework to help students improve computer skills and understanding. However, this approach was met with dissatisfaction from parents. Teacher G explained "I received many complaints about assigning homework tasks to students. The girls, in particular, had limited computer skills and lacked access to a desktop computer at home. Many of them were not even familiar with what a computer was".

The issue of students' access to technology was more or less better during the COVID-19 pandemic, since students were accustomed to mobile devices and participating in online

classrooms. However, the persistent lack of desktop computers in schools, coupled with the widespread use of mobile devices such as iPhones and iPads, presented limitations in students' ability to acquire fundamental computer skills. These skills include typing on physical keyboards and using a mouse for navigating computer screens. In the focus group interview and reflection essays, teacher G highlighted the challenges she faced, particularly with fourth graders. She explained "I encountered significant difficulties, especially with fourth graders. Many of them were unfamiliar with desktop computers and often confused them with cell phones or iPads. They lacked the know-how to use MS Windows or perform basic tasks like right and left mouse clicks".

As a result of these technology barriers, some participating teachers have advocated for schools to provide desktop devices to supplement the computing curriculum for students. For instance, teacher N emphasized the importance of establishing computer labs within schools: "it is essential to provide computer labs in schools. As students will not fully benefit from theoretical explanations, especially the digital generation". Aligning with this call, teacher G reflected on the reason in her essay: "The subject [Digital Skills] is primarily based on practice and experience". While teacher B reflected on the potential impacts: "The lack of computers and the lack of applications on devices leads to varying student understanding and goal achievement". This call seems reasonable considering the cognitive developmental stage characteristics of elementary school students. According to Piaget's theory of cognitive development, children in the concrete operational stage, which includes elementary and early adolescence, rely on hands-on experiences with tangible objects to understand and manipulate symbols [70]. Effective learning strategies for this stage involve hands-on, experimental activities, closely tied to the subject matter [71]. These characteristics have two key implications: the importance of a constructivist approach to learning and the potential difficulty in grasping abstract concepts, such as computing clouds, search engines, and CPU processors without hands-on experiences.

Conflicting perspectives. Since most participating teachers held two positions, in-service teachers and students in the CSPD programs, they were evaluated and provided feedback on their teaching practices by school supervisors and university faculty members. The school supervisors assessed their CS teaching practice and pedagogy in real classrooms, and the faculty members assessed their CS teaching practice and pedagogy in micro- and macro-teaching sessions in the CSPD program. The findings revealed that supervisors and faculty members applied distinct assessment standards, causing the participating teachers to encounter difficulties in interpreting their feedback. These teachers often expressed a misalignment between the objectives of the CSPD program and the evaluation criteria employed by school supervisors in the classroom. One example illustrating a conflict in teaching approaches is that teacher S faced differing opinions from her supervisor and a faculty member regarding the use of PowerPoint slides. In this scenario, teacher S expressed concerns during a micro-teaching session when a faculty member advised her to reduce the amount of text on PowerPoint slides and abstain from including segments of the digital curriculum book. Her supervisor had previously mandated the inclusion of book-related images on slides to prevent slides from appearing empty and to enable students to review the material. Teacher S was unsure how to handle the conflicting perspectives of her supervisor and the faculty member, and she asked the faculty member for a solution. This challenge was explicitly brought up in her reflection essay and the focus group interview, as she explained "The first critique from a supervisor would likely revolve around the lack of content in your presentation. The standard she follows is to present the entire lesson from the digital book in front of students. When I discussed this issue with her last semester, she insisted that since students do not possess physical copies of the book, we must place the book's content in front of them". Other teachers echoed teacher S's concerns. For example, teacher G said, "Since last year, the book has been converted into a digital version and it honestly bothered us".

Another instance within the context of teaching CS is that teacher S encouraged her students to practice their computer skills on her desktop computer, following the approach

she had learned in the CSPD program. However, the school principal provided different guidance. The principal emphasized managing the class and preventing students from leaving their chairs to use the desktop. Teacher S continued "The reality often differs from the university setting. This is what we have been told, but I have personally experienced it". Therefore, teacher S suggested that supervisors should gain a better understanding of the PD program attended by teachers, including its objectives and curriculum. She believed that this understanding would help align teachers' learning with the vision of supervisors and principals. In her view, connecting the program to educational trends and practices would benefit everyone involved, ensuring that teachers receive adequate support and evaluation standards. Several other teachers endorsed her viewpoint. This finding is consistent with the existing literature, which indicates that the lack of collaboration between higher education institutions and local school organizations acts as a significant barrier, impeding the long-term effectiveness of professional development in shaping teachers' practices [20].

5.2.3. Implementation Challenges

This section focuses on challenges related to the CSPD implementation encountered by the participating teachers. These challenges include time management, limited supervisor support, as well as passive learning and teaching practices.

Time management. Another significant challenge faced by participating teachers was the burden of a high workload. Balancing the roles of being both a teacher and a student simultaneously placed a heavy workload on teachers, adding to their existing life and school responsibilities. Teachers needed to manage their time wisely to keep up with teaching and studying commitments. Nearly every participating teacher expressed the overwhelming time when having both teaching and learning tasks. For example, teacher M said "we were stressed. In the morning, you had to teach. You also had to study. It was a bit of a pressure for us". This finding is consistent with the existing literature that highlights the challenges faced by in-service teachers in balancing their teaching and responsibilities within PD programs [31,39].

Alqahtani [45] examined factors that influence the effectiveness of PD programs in Saudi Arabia. He found that heavy workload was a significant factor that negatively affected the outcomes of professional programs. The teachers in Alqahtani's [45] study expressed that having teaching and non-teaching assignments limited their opportunities to apply PD gained knowledge and ideas. A study by Najmi and Alwadani [72] investigated the degree of student teachers' satisfaction who were enrolled in the critical thinking PD program as part of the optimal investment project for education personnel. Najmi and Alwadani found that the high number of courses per semester posed a challenge for the participants. Agreeing with their study, many teachers of the present research professed that having sabbatical leave conditions would make PD manageable. Teacher S recommended allowing teachers to have sabbatical leave: "the whole program was wonderful, and left us with many beautiful memories. The courses were highly valuable, making us wish we had sabbatical leave", since it was hard for them managing all responsibilities at the same time, "the experience of participating in the PD program was beautiful, but there were difficulties. Managing studying, teaching, and other obligations all at once proved to be a challenge". The participating teachers pointed to the need for sabbatical leave during the program, and considered being both the teacher and student simultaneously as a challenge. Teacher A, for example, described how attending the PD program after the school day ends was hard for the other participant teachers, but not for her since she was in a sabbatical leave: "time and workload were obstacles for the teachers who were teaching in the morning, but it was easy for me as I was on sabbatical leave". The desire for the sabbatical leave could be reasonable, especially if the PD programs entail new teaching knowledge, methods, and strategies. Teachers need time not only to understand, apply, or practice the newly gained information, but also to design and implement it into lessons. With the high volume of the daily work of planning lessons and teaching activities, teachers might not have

time to try out or prepare new teaching methods and strategies [45]. Based on the study findings, one recommended solution to address the challenges of the heavy workload is the implementation of sabbatical leave, allowing teachers to make effective use of their time to accomplish the teaching goals of the programs.

Limited supervisor support. While teaching the CS curricula, teachers attempted to seek support from their supervisors to overcome CS teaching difficulties and bridge gaps in their knowledge and practices. However, due to the high number of teachers under supervision, they received no assistance from their supervisors. This shortage of support caused some teachers to play a passive role in their students' learning. On one hand, some teachers resorted to self-learning strategies, primarily relying on e-learning resources as their main teaching method. Teacher M recognized the drawbacks of using pre-recorded video files as the primary learning resource for elementary school students, noting "My students did not acquire digital skills because the teacher who took over after me lacked experience and only played pre-recorded videos on the national learning platform. There was no practical application or interaction". Research indicates that the interaction between teachers and students is essential for supporting cognitive development and comprehension [73,74]. Thus, elementary school students cannot achieve optimal learning outcomes through a sole dependence on external electronic resources.

On the other hand, other participating teachers turned to the internet for immediate support and self-studies. They expressed frustration at having to navigate this journey without guidance. They lacked the knowledge of suitable CS teaching methods, struggling to apply them effectively to achieve desired outcomes. Teacher G, who had two years of CS teaching experience, shared her perspective, stating "I focused on self-improvement, but it was all up to me. I joined computer teacher groups on Telegram, watched videos, and subscribed to YouTube channels. While I gained some benefits, I could not improve without guidance or supervision on how to develop myself. Teaching digital skills left me feeling confused; I made some correct decisions and also made mistakes. When I recognized my mistakes, I had to inform my students and seek corrections". In her reflection essay, she emphasized the lack of support from schools: "Most primary schools do not give importance to the subject [Digital Skills]". Lyonga [75] emphasized the importance of supervision in promoting best teaching practices and ensuring educational quality. By regularly assessing teachers' performance, they can identify their strengths and weaknesses, enabling them to plan for improvement with guidance and constructive feedback [75]. This approach empowers teachers to make informed decisions regarding participation in training workshops, online courses, or other PD opportunities that align with their specific needs, rather than wasting time and resources on sessions that may not address their unique requirements.

Passive Learning and Teaching. Another challenge related to the program's nature and requirements is utilizing a lecture-based teaching approach as the sole method. Lecturing without incorporating other forms of learning led to boredom and passivity among learners. Teachers N, G, and A expressed their perspectives on this issue. Teacher N remarked: "It was extremely tedious, and we really got bored of it. Imagine, there was no tonal variation, no participation, and no one said anything. It was the last lecture of the day, and it took place at night, so we were already feeling sleepy. Frankly, it felt like a bedtime story... The material was originally good and impractical, but the recitation added rigidity... we did not enjoy it". Teacher G added "It was overly theoretical and lacked depth", while Teacher A concurred, stating "It was very shallow".

Learning becomes even more challenging when teaching topics that require hands-on activities. In this regard, the participating teachers received verbal instructions on creating videos and were subsequently asked to submit their work. Teachers M and N shared their experiences of feeling lost and uncertain about whether they had met their learning objectives. Teacher M expressed their frustration, saying "We had a lecture on hologram technology, and then we were expected to apply it practically in a video. The topic alone felt intimidating, and we were asked to design the video with only the purpose

in mind, without providing any detailed instructions". Teacher N echoed the sentiment, emphasizing the lack of guidance "It was actually frustrating when the topic was assigned, and we were requested to create the video without any explanation or guidance. We needed her to explain and guide us. Being a faculty member, teaching is not supposed to be difficult, but leaving us feeling lost and having to rely on each other for clarification. None of us truly understood". These findings align with the literature, emphasizing the need for elementary teachers to receive PD on active teaching practices [28].

5.3. The Main Research Question: How Do In-Service Teachers Perceive Their Experience in the Professional Development Program of Computer Science?

The CSPD program is designed to equip teachers with the necessary knowledge and skills to teach computing curricula in elementary schools. The participating teachers enroll in this program need to change their path to fulfill the requirements of qualified CS teachers in schools. The participating teachers emphasized the need for the CSPD program. For example, Teacher M explained "With the addition of the Digital Skills subject to elementary schools, we indeed need the professional developmental program". The rapid global adoption of new CS curricula necessitates an enhanced understanding of effective teaching practices and strategies to develop teacher capacity in this field [76].

Furthermore, some of the participating teachers reported that prior to enrolling in the CSPD program, they had attended various training sessions to address gaps in their CS knowledge and teaching pedagogy. However, they expressed dissatisfaction with the results, as these sessions did not significantly enhance their teaching practices or benefit student learning. Teacher G described one of the training courses as useless, indicating a lack of effectiveness in improving their instructional abilities. She said "they gave us some simple highlights in the course. The course lasted for two hours... simple things were presented and some mistakes in teaching based on our teaching... but it was not as a training course". This result emphasizes the importance of PD program quality, including the program components. Undoubtedly, teachers are a critical component in the educational process, and they even play a more important role if they are qualified and have appropriate PD programs [69]. The UNESCO Teacher Policy Development Guide places a strong emphasis on the importance of acquiring a comprehensive understanding of content and pedagogical strategies specific to the desired educational level [77]. Thus, designing PD programs that are responsive to teaching practices and needs is crucial to minimizing the challenges of implementing unrealistic knowledge.

The findings indicate that the CSPD program has successfully enhanced teachers' capabilities to teach computer science in elementary schools. The participating teachers highlighted the CSPD program's positive impact on their PD. While reflecting, teacher S stated "I felt and perceived the magnitude of progress I had made". The program achieved this through various components, including subject content and micro/macro-teaching. Effective pedagogy, such as active learning strategies and reflection essays, also played a significant role in improving teachers' instructional practices. The program resulted in positive changes in teachers' self-efficacy, beliefs, and learning/teaching approaches, further strengthening their capacity to deliver CS education. By improving teachers' capacities in this field, the research supports the development of a sustainable workforce equipped with the necessary skills for the digital age. This, in turn, contributes to the long-term sustainability of industries and economies that rely on technology and education.

However, the PD program also faced certain challenges. Prerequisite skills challenges emerged, particularly in the areas of self-directed learning and scientific research skills. Overcoming these challenges required additional support and resources. Other challenges were also identified, including pre-implementation issues and implementation obstacles. Addressing these challenges would be crucial to ensure the smooth and successful of the CSPD program. Table 4 summarizes these themes.

Table 4. Features and challenges of the CSPD program.

Features of the CSPD Program Helped in Enhancing Teachers' Capacity	Challenges Encountered in the CSPD Program
1. PD program components • Subject content • Micro- and Macro-teaching	1. Prerequisite skills challenges • Self-directed learning skills challenge • Lacking scientific research skills
2. PD effective pedagogy • Active learning • Reflection essays	2. Pre-Implementation challenges • Relocating teachers to the university city • Insufficient school technology • Conflicting perspectives
3. Changes in CS self-efficacy, beliefs, and practices • Learning and teaching self-efficacy and beliefs • Learning and teaching practices	3. Implementation challenges • Time management • Limited supervisor support • Passive learning and teaching

Building upon the concept of a community of practice, the CSPD program discussed in this context manifested as a community when the participating teachers shared similar teaching concerns, came together to practice and learn better strategies, and interacted collaboratively and regularly in a supportive environment. This community helped the teachers to develop and improve their skills as educators. The teachers were able to exchange ideas, query experts, clarify ambiguities, address concerns, expand their knowledge, and receive learning, and teaching support. These interactions were formed through frequent discussions and teaching situations involving both the faculty members and the teachers. A significant example was the regular, semester-long micro- and macro-teaching sessions. These sessions played a crucial role within the community of practice by enabling teachers to actively observe and practice teaching, reflect on practices, and integrate valuable feedback. This resulted in an improvement in their knowledge and pedagogy of CS teaching. The teachers, along with the faculty members, formed a supportive network to share ideas, resources, insights, and experiences.

6. Conclusions

The research results provide valuable insights into the outcomes of the CSPD program for teachers in elementary schools. The experiences of the teachers indicated that the CSPD program had a positive impact on elementary school teachers' ability to teach CS. These findings align with the existing literature, emphasizing the crucial requirement for K-12 CS teachers in PD programs to possess programming skills [4,55,58]. Moreover, these findings are consistent with other studies [25,62] that have also shown the positive impact of CSPD on teachers. The current study CSPD program positively enhanced the teachers' teaching capacity by providing relevant program components, emphasizing effective pedagogy, and fostering changes in teachers' beliefs and self-efficacy. Overall, the CSPD program enhanced their knowledge, skills, and confidence in teaching CS to elementary school students. Therefore, a community of practice is highly recommended as a supportive framework for effective PD in CS. Furthermore, the findings highlighted the existence of challenges associated with prerequisite skills required for enrolling in the CS teachers PD program, specifically self-directed learning skills and research skills. To address the shortage of self-directed learning skills and research skills, it is highly recommended to introduce initiative courses. These courses would be specifically designed to address these skill gaps and provide targeted training and support to individuals, enabling them to develop and enhance their abilities in self-directed learning and research skills. Based on the findings, it is suggested to investigate the challenges and effective strategies for improving prerequisite skills like self-directed learning and research skills for teachers enrolling in PD programs.

Moreover, the study reveals various pre-implementation challenges and implementation challenges, including the processes of relocating teachers, time management, insufficient school technology, limited supervisor support, conflicting perceptions, and issues related to program content delivery. These findings underscore the importance of addressing these challenges and providing targeted support to ensure the successful implementation and effectiveness of PD programs for CS teachers. Facing these challenges, the participating teachers acknowledged the necessity of PD programs for bridging the gaps in their knowledge and teaching practices. By addressing these aspects, the study contributes to the broader goal of integrating sustainability principles into education systems and preparing individuals for a sustainable future.

In addition to these valuable findings, it is crucial to acknowledge the limitations of this study to ensure a well-rounded understanding of the topic. One potential limitation of this research is its specific focus on the outcomes of the CSPD program for elementary school teachers. This narrow scope restricts the generalizability of the findings to other grade levels or educational contexts. To obtain a more comprehensive understanding of the program's impact, it would be beneficial to explore its effectiveness across various grade levels and school settings. Another limitation of the research is that the sample consists solely of females. Examining male teachers could uncover different experiences and perspectives, providing a more comprehensive understanding of the topic. In addition, the potential long-term sustainability of the observed positive outcomes was not addressed in the research. Understanding the long-term impact of the program would provide insights into its effectiveness and inform future implementation strategies. Thus, it is recommended for future research to study the long-term effects of the CSPD program on teachers' ability to teach CS in elementary schools over an extended period. Examining faculty member perspectives is another path to enrich teacher experience and the development of CSPD programs.

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