



Current Experiences and Factors of Future Enrollment in Computer Science for High School Students

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Abstract

This study aims to examine the current experiences of high school students in computer science (CS) courses and the factors that motivated them to continue their future enrollment. The participants were 603 high school students in grades 9 through 12 in Indiana, all of whom enrolled in at least one CS course during the 2020-2021 academic year. This research revealed that fun and meaningful CS pedagogy, knowledgeable CS teachers, and relevance to their lives and future careers enabled high school students to hold positive experiences in their CS classes. These experiences impacted students to take additional CS courses. In addition to these positive experiences, gender and early exposure to CS emerge as predictors to pursue CS courses. The findings will carry significance for policymakers and educators offering insights to enhance and broaden students' participation and engagement in the CS course.

Keywords Computer Science · CS experiences · High school students · Predictors of future enrollment

Introduction

Stakeholders and scholars have suggested that all K-12 students need to learn about computer science (CS) for multiple reasons including supporting other learning, growing labor market, civic participation, and social justice (Code.org et al., 2022). However, there is low participation of underrepresented groups in Advanced Placement (AP) CS

exams meaning that CS tends to exclude a wide range of the population including women, Black, Latinx, students with disabilities, etc (Ericson, 2021). Within the CS education field, many have sought out ways to examine and measure equity, utilizing the CAPE framework which addresses four key components: *Capacity for*, *Access to*, *Participation in*, and *Experience of* equitable CS education (CAPE) (Fletcher & Warner, 2021). Many states have required high schools to offer CS courses and students to take at least one CS course before graduation (Code.org et al., 2022). Although these policies address the capacity, access, and even participation for equity as presented in the CAPE framework, not many students take CS courses in high school. Although 91.7% of high school students in Indiana, U.S. attend a school that offers CS courses, only 5.8% of students took CS courses (Code.org et al., 2022). To encourage students to take CS courses and promote students' participation in CS, we need information on current CS experience.

Importance of K-12 CS Education

More attention has been allocated to K-12 CS education due to increased CS jobs (*Computer and Information Research Scientists*, n.d.). Computer and computer-related jobs are expected to grow 13% from 2020 to 2030 with

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higher than the median annual wage of all other jobs (U.S. Bureau of Labor Statistics, 2022). In Indiana, there were averaged 7,900 open computing jobs each month in 2022, but only 2,544 graduates in CS in 2019 (Code.org et al., 2022). The labor force has indicated that we need more people in CS, especially underrepresented populations. Women, Black, and Hispanic are still underrepresented in the STEM workforce where they represent only 25%, 9%, and 7% respectively among STEM workers (Funk & Parker, 2018). It is important to have a diverse background of people included in the workforce because they have different knowledge, perspectives, and cultures that are needed for innovative ideas of products and services (Varma, 2018).

Factors of CS Participation and Persistence

There are numerous studies that examine factors pursuing CS. Studies have identified the reasons for enrolling in CS include early exposure to CS (Beyer, 2014; Jones & Hite, 2020; Tran, 2018), curriculum selection (McGee et al., 2016; Morrison & Preston, 2009; Papastergiou, 2009), and career aspirations in CS (Masnick et al., 2010). Also, family, friends, and teachers have been recognized as critical factors that drive students' decisions to take CS (Alshahrani et al., 2018; Wang et al., 2015). Other factors such as gender have also impacted student enrollment in CS (Beyer, 2014). The study conducted by Giannakos et al. (2017) identified what predictors influence the completion of a CS major in higher education. They concluded that the usefulness of CS is the factor affecting whether to continue CS and cognitive gains and supportive environments influenced this usefulness. In addition, they highlighted that negative feelings are associated with discontinuing the college student's CS major. In the study of Beyer (2014), college students responded that negative experiences such as dissatisfaction with teachers made them not want to take any additional CS courses, even with other CS teachers. In addition, positive CS experiences in students' first CS courses influenced students to decide to take additional CS courses (Beyer, 2014). Kapor Center (2021) examined the six components to create equitable and sustaining CS classrooms, which are (a) anti-racist practices, (b) inclusive and equitable classroom cultures, (c) relevant and rigorous pedagogy and curriculum (d) student voice, agency, and self-determination (e) family and community cultural assets, and (f) diverse professionals and role models exposure to CS careers. Numerous studies (Beyer, 2014; Giannakos et al., 2017) have been investigated within higher education. Also, only limited studies were conducted with a large number of participants. Thus, there remains a need for more information in the high school context in a large population to examine the factors affecting CS enrollment.

Gender Differences in CS Participation and Experiences

Many researchers have highlighted and documented that women have little involvement in participation and representation in CS-related fields (Kelly et al., 2013; Wang et al., 2015). Also, there are numerous studies comparing males and females in CS. Beyer (2014) demonstrated that male students had a more positive attitude toward taking CS courses than female students. Wang et al. (2015) also highlighted that female students were less likely to be confident to learn CS than boys. Moreover, there are perceptions and stereotypes that white males are doing CS jobs (Wang et al., 2016). This aligns with the Indiana high school statistics. In Indiana, within the enrolled student population in CS, the representation of female students accounted for only 22.5% (Code.org et al., 2022). However, we need more information on why female students are less represented in CS courses so that policymakers and educators can establish strategies to broaden CS participation for female students.

Purpose of Study

Even though the demand for CS professionals is increasing considerably, few studies have examined what factors affect students to pursue CS (Giannakos et al., 2017). We still lack information on students' experiences within their CS courses in high school. Some studies have examined students' experiences and participation through AP exam scores (Bahar et al., 2022; Howard & Havard, 2019), but there are still few studies that examine wide-spread students' experiences in all high school CS courses, and the factors that contribute to both positive and negative experiences in their CS courses that may contribute to their continuation in CS coursework. High school students are the potential selves to solidify their commitment to CS-related fields before they enter college and seek out technology-related careers (Kelly et al., 2013). Among K-12 students, specifically high school students are a critical student population to examine in CS education as they are the future of the field of CS. If high school students are not motivated in CS, this will impact their future careers. Therefore, we examined more than 600 high school students' current experiences in CS courses and the factors that motivated them to continue their enrollment through the following questions:

1. What were the positive and negative experiences of computer science courses high school students had?
2. What were the factors that influenced high school students' future computer science enrollment?

Method

The aim of this study was to understand high school students' experiences in CS and the factors that influenced future enrollment in CS. This study employed a mixed-method design (Creswell & Clark, 2017) utilizing both qualitative and quantitative approaches, and data were collected using an online questionnaire constructed by researchers.

Participants

The participants were 603 high school students in Indiana from 9th to 12th grade, who enrolled in at least one CS course during the 2020–2021 school year. These courses included Introduction to Computer Science, Computer Science I, Computer Science II, Computer Science III, AP Computer Science A, AP Computer Science Principles, IB Computer Science Standard Level, and IB Computer Science Higher Level.

Data Collection

Data was gathered over a one-month period (May 2021–June 2021). The researchers sent an email to high school CS teachers, asking them to distribute the questionnaire link privately to their students. Students had the option to opt out of the questionnaire; no personally identifiable information was collected. All students were provided with a study information sheet that explained the purpose of the study with an assurance of confidentiality.

The online questionnaire consisted of 15 possible items which included follow-up items using skip logic. First, demographic information such as gender, grade, and ethnicity was collected. In the second section, all students were asked whether or not they had previous CS experience. This section also included items on which CS courses they were taking at the time and whether these courses were their first CS courses. The third section asked students to reflect on their CS experiences. The items in this section asked students to reflect on their experiences in their CS classes, as well as their rationale for why their experience was positive or negative. In the fourth section, all participants were asked whether they would enroll in future CS courses. Data for this paper were primarily drawn from sections three and four.

Data Analysis

In Research Question 1, we examined which characteristics of CS courses students experienced as positive and negative. For example, was the teacher or the curriculum critical to students' negative or positive experiences? We also included

all senior students in this part of the analysis. Although senior students would not be taking any future CS high school courses as this was their last year in high school, understanding their experiences would still allow us to understand some other students' experiences in CS classes.

To analyze the open-ended items, a constant comparative analysis process was conducted as a method for consistently challenging our codes and refining the data into clear categories (Glaser, 1965). The research team consisted of six educational experts with previous K–16 computer science educational experiences. One open-ended question asked about students' experiences in high school CS courses, which received 574 unique student responses. Based on an initial review of all the responses, the six researchers collaboratively created an initial codebook with themes, definitions, and example quotations. Next, three members of the research team reviewed every one of the students' responses and coded them. After all responses had been coded, we looked across the codes to identify the responses that were not identically coded (resulting in 42 codes). Then, we collaboratively discussed these student responses and deconflicted all codes that were not identically coded.

Once the final codes were established, we created a table that contained definitions and examples of each code (See examples of a selection of the most common codes in Table 1).

In research question two, we identified the factors that influenced high school students' future CS enrollment. We asked if a student will take any more high school CS courses. 12th-grade senior students were excluded, as the time they conducted the survey was their last semester in high school. Therefore, we included 474 students' responses in the analysis as they were currently in 9th to 11th grade (freshman to juniors). Five independent variables were used to examine: gender, grade, race, CS experience before high school, and previous CS courses in high school. These factors were based on previous studies and results found in the literature around why students continued in CS career paths (e.g. Giannakos et al., 2017; Hawlitschek et al., 2019; Krpan et al., 2015; Palmer et al., 2017; Wang et al., 2015). To analyze data for this question, we conducted a logistic regression (Hosmer Jr et al., 2013) to predict the dichotomous categorical results from the potential factors that could impact students' future enrollment in CS. The formula for the logistic regression model for this study is below. $\pi(x_i)$ indicates the probability of future CS enrollment.

$$\log \frac{\pi(x_i)}{1 - \pi(x_i)} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n$$

Furthermore, the closed-ended items, such as selecting the reason why students will continue or stop taking CS,

Table 1 Most common codes

Code	Definition	Example
Learn	Mentioned learning something. Can be specific or just a general comment.	“It helps me understand...” “Understanding them more and more...” “I was able to learn a lot about coding” “We covered a lot of cool and different topics...”
Fun	Mentions fun or enjoying CS or specific activities	“I had fun doing coding activities and overall enjoyed the class.”
Teacher	Any mention of the teacher	“I really enjoyed taking them because of my teacher. My teacher is an amazing teacher and has taught the principles of computer science.” “I really enjoy this subject, I like learning about my interests.” “I got to see and explore how computer science principles apply to real life.” “Because I easily related the material I learned to everyday life.”
Relevant	They see the relevance of CS based on the class and how it might apply to their futures. Perhaps even future career choices or current life.	“I have had some positive experiences, mainly when it came to implementing creative writing or designing a website since there is more room for creativity in it.” “I was able to work collaboratively with others on projects early on while learning. Later, I was able to move onto more independent projects with which I could fully explore.” “I found the PLTW curriculum boring.”
Hands-on	Specifically talks about coding or being able to do something active or hands-on	
Curriculum	Specifically mentions an activity, lesson, or curriculum that motivated them to have a positive experience (this could be certain projects or the hands-on aspect).	

were analyzed using descriptive statistics that included frequency counts and percentages.

Results

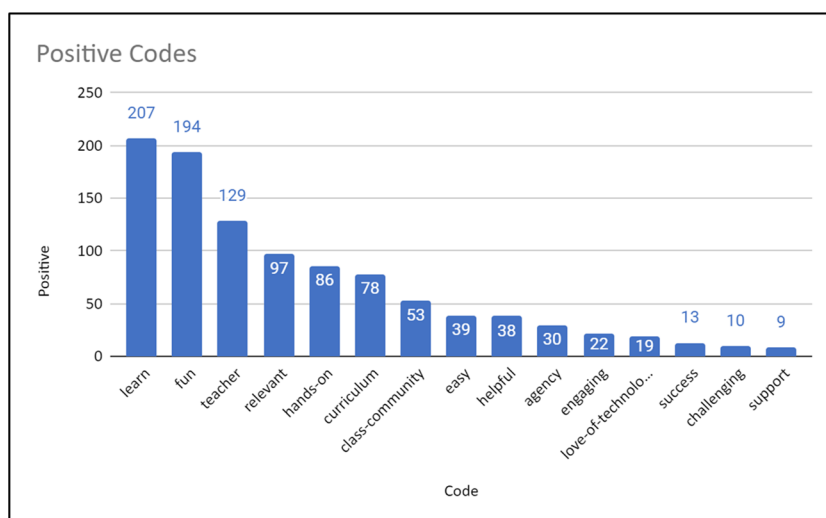
Current Experiences of CS Course

To examine whether students had positive or negative experiences, we analyzed item #7, which asked students “Did you have positive experiences in your high school computer science class(es)? Why or why not?” This question was an open-ended question where the students first answered if their experience was positive or negative and then followed up with reasoning for this answer. There were 574 student responses to this question. Results showed that most students ($n=540$) described having positive experiences within their high school CS courses, whereas ($n=90$) students described having negative experiences. Each of the student’s responses could be coded as both positive and negative. For example, S37 had an experience that was coded as both positive and negative, “Not until Cybersecurity. I hated and still hate coding. Also I had problems keeping up with the curriculum. Cybersecurity was easier because it had less to do with coding and more security”. This is the reason that there were more than the original ($n=574$) unique student responses. Additionally, one code could be framed in both a positive and negative way. For example, the code *teacher* could be classified as positive for some students and negative for others. An example of one code being classified both positive and negative would be first from S70 who classified their experience with their teacher as positive, “I had many

positive experiences in my high school computer science class. I learned a lot of new things because my teacher was very good at explaining things and describing how things worked.” However, S134 reported an overall positive experience with CS classes, but a negative experience with their teacher: “I have had generally positive experiences in high school CS courses. I enjoy programming, so the content is interesting to me and I am able to learn fairly independently. I will say, especially this year, the teaching staff that I’ve had is somewhat underwhelming. I get a sense of general disinterest from my teachers in regard to my projects, the class work, my grades, my questions, and even about computer science in general. I understand that CS can be very independent at times, but personally, I don’t feel like my teachers care about the class they teach” (S134). Below is a more in-depth result of the positive and negative experiences and codes associated with these experiences.

Positive

Figure 1 shows each of the codes that were classified as a positive response for CS courses along with how many times the codes were used throughout all of the responses. Each response usually received more than one code describing the students’ experiences in their computer science class. For instance, the code *learn* which was the highest coded positive response ($n=207$), was associated often with the codes *fun*, *hands-on* (the fifth highest coded positive response), and *teacher* (the third highest coded positive response). A quote exemplifying this is, “Yes very much so. My teacher did an amazing job of making learning CS fun and engaging while encouraging us the students

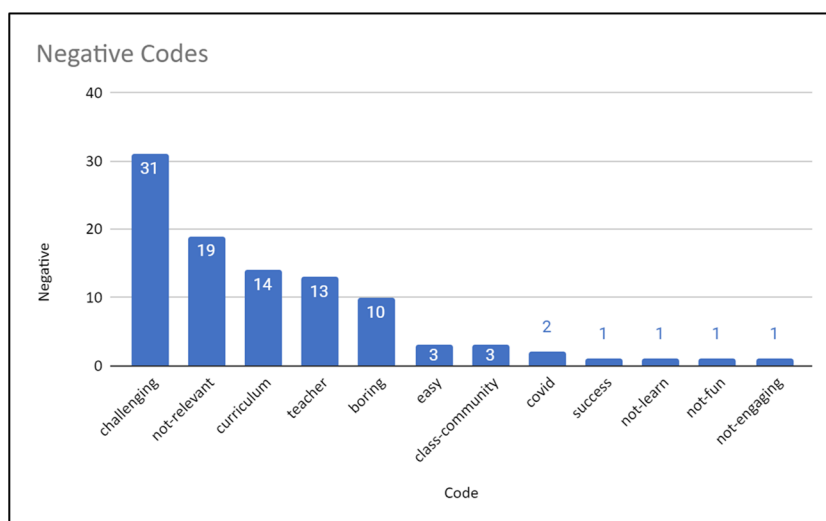
Fig. 1 Positive codes of CS experiences

to explore other parts of CS that we wouldn't really touch on in class" (S85). Further, the code *learn* might also be associated with codes such as *relevant* (the fourth highest coded positive response) and *curriculum* (the sixth highest positive response). An example quote showing this relationship came from S269, "The experience I had during APCSP was positive. It made me remember how much I enjoy coding like I did in elementary school with the hour of code. I hope to have the same amount of joy when I take APCS Java next year. I hope to have my major in college to be computer science" (S269). The code *learn* was often seen associated with the code *fun*. Many of the positive experiences came from students who had fun while they learned and the codes such as *hands-on*, *teacher*, and *relevant* seemed to be enablers of the fun that was had during learning. The Discussion section will make suggestions on how to make a more positive class experience.

The second highest coded response was *fun*. As discussed above this code was seen in conjunction with the code *learn* often. It was also seen in conjunction with the code *teacher*. For instance, S469 reported, "Yes, I had a great time learning the material, which was very interesting, and my teacher also taught in a fun way." Further, the code *fun* was also associated with the code *class community* S25 describes their experience with the class as, "Very interesting and fun to collaborate with friends." These two quotes show that both the teacher and the students in the class can contribute to the class being fun.

Negative

Overall, the perception of the CS classes in Indiana was positive; however, there were negative experiences associated with CS classes. Figure 2 below is a synopsis of the codes which were coded as negative responses to the CS course. The code,

Fig. 2 Negative codes of CS experiences

challenging (n=31) was the most cited reason for a CS course being negative. There were different reasons for the students such as the workload being too much, “No because it was hard and too much for me to handle with all my other classes” (S311) or having issues with the concepts of CS, “somewhat I just have trouble remembering code and what it does” (S375) and “No, it was very hard for me and never ‘clicked’” (S444). Most of the responses being classified as *challenging* only had challenging as its code. The code *not relevant* (n=19) was also used frequently as a code to classify a negative experience. Many of the students did not see the class as relevant because they did not see it as relevant to their future careers or their daily lives, “No. The coding experience I have is exclusive with javascript, which is not applicable for the major I am going into” (S10) and “Meh. I learned a few things but I doubt it will be very useful” (S264).

There were a few codes that received both positive and negative coding. One example of this was the code *teacher*. This code teacher did receive more positive than negative codes, but it is important to investigate the reasons this code also received negative coding. Most of the negative coding was due to the student’s perception of lack of teaching supports as S420 and S511 report, “I had a neutral experience. I feel like my teacher did not properly teach us the code. I needed more support and more detailed explanations throughout the year. Although, this was her first year teaching this course, so maybe that was the reason” (S420) and “No, it was honestly an awful experience. My teacher did not teach us well enough and it has made me have an awful perception of Computer Science” (S511). The *curriculum* was another code that also received both positive and negative coding. Most of the negative coding centered around the curriculum not being authentic as stated by S612 and S614, “No, because while in a classroom setting, computer science cannot be taught. We also used [code.org](#) which did not teach me anything about coding” (S612) and “No, because computer science was not taught in a meaningful way. I was told to go on a website and use fake coding (on [code.org](#)) and learn how to code that way. It did not teach me anything more about coding than I already knew, and I still could not sit down and write even simple code” (S614).

Predictors and Reasons for Future CS Enrollment

We investigated the predictors of future high school CS enrollment and their reasons to continue or discontinue. Since this survey was conducted the last semester for seniors, the subset of the data included freshmen, sophomores, and juniors. The total number of students was 474. Table 2 shows the demographic background data categorized by gender, grades, race, and previous CS experiences.

We calculated the frequency of responses of students taking more high school CS courses in the future (see Table 3). Among 474 students, 238 male students (63.8%) out of 373 responded yes to taking more high school CS courses while

Table 2 Demographic background

Factor		Responses	%
Gender	Male	373	78.7
	Female	101	21.3
Grade	Freshman	139	29.3
	Sophomore	178	37.6
	Junior	157	33.1
Race	White	356	75.1
	Asian	42	8.9
	African American	23	4.9
	Hispanic	14	3.0
	*Other	39	8.2
Previous CS Experiences before High School	Yes	273	57.6
	No	201	42.4
First CS Course in High School	Yes	339	71.5
	No	135	28.5

Note: * includes Native Hawaiian or Pacific Islander, Middle Eastern, American Indian or Alaska Native, and Mixed races

only 36 female students (35.6%) out of 101 responded yes to taking more CS courses. 75.5% of freshmen responded yes to taking more CS courses whereas sophomores’ rate was 48.9% and juniors’ rate was 52.2%. 64.5 % of students who have previous CS experiences before high school responded yes to taking more high school CS courses. The positive response of students who didn’t have CS experiences before high school was 48.8%. 68.4% of students who are not the first CS course takers in high school said yes to this question while 53.4% of students who are the first CS course takers in high school responded positively to taking more CS courses.

Our team conducted a logistic regression to identify the predictors of future CS enrollment in high school. We used five variables as independent variables: gender, grade, CS experience before high school, first high school CS course, and ethnicity. Table 4 shows model coefficients of future CS enrollment predictors. Among five independent variables, gender, grade, CS experience before high school, and first CS course in high school were significant predictors of future CS enrollment; race was not identified as a significant predictor. However, this could have been due to the smaller sample size of non-White students.

An odds ratio of less than 1 indicates that the variable decreases the likelihood of future enrollment. Gender was a significant factor in whether or not students will take more CS courses in high school (Wald=19.003, $p < .001$). Female students indicated that they were less likely to enroll in CS courses in the future than males. The likelihood of future enrollment of female students decreased by 67.2%. Male students expressed they were 3 times more likely to enroll in CS courses in the future than female students. Thus, high school students have different future enrollment by gender.

Table 3 Plan to take more high school CS courses

Factor		Yes	Y (%)	No	N (%)	Total
Race	White	205	57.6%	151	42.4%	356
	Asian	29	69.0%	13	31.0%	42
	African American	11	47.8%	12	52.2%	23
	Hispanic	10	71.4%	4	28.6%	14
	Other*	19	48.7%	20	51.3%	39
Gender	Male	238	63.8%	135	36.2%	373
	Female	36	35.6%	65	64.4%	101
Grade	Freshman	105	75.5%	34	24.5%	139
	Sophomore	87	48.9%	91	51.1%	178
	Junior	82	52.2%	75	47.8%	157
Previous CS experience before HS	Yes	176	64.5%	97	35.5%	273
	No	98	48.8%	103	51.2%	201
First CS course in HS	Yes	181	53.4%	158	46.6%	339
	No	93	68.9%	42	31.1%	135

Table 4 Model coefficients of predictors of future CS enrollment

	B	SE	Wald	df	Sig	Exp(B)
Constant	2.050	0.364	31.653	1	< .001	7.771
Gender (Female)	-1.114	0.256	19.003	1	< .001	0.328
First CS in High	-1.006	0.252	15.928	1	< .001	0.366
Pre CS Exp before High	0.440	0.252	4.367	1	.037	1.552
Grade			31.597	2	< .001	
Grade (Sophomore)	-1.411	0.272	26.932	1	< .001	0.244
Grade (Junior)	-1.445	0.293	24.420	1	< .001	0.236
Race			5.699	4	.223	
Race (Asian)	0.621	0.384	2.615	1	.106	1.861
Race (African American)	0.075	0.471	0.025	1	.874	1.007
Race (Hispanic)	0.359	0.663	0.293	1	.588	1.431
Race (Others)	-0.538	0.360	2.227	1	.136	0.584

Another influential variable in the model was the first CS course in high school (Wald=15.928, $p < .001$). If the current CS courses were not the first time that students took in CS high school, they were 2.7 times more likely to enroll in another CS course in the future than students who took this as their first CS course in high school. Student grade levels (Wald=31.597, $p < .001$) are also statistically significant. Freshmen were more likely to enroll in future high school CS courses than sophomores and juniors. Sophomores indicated that they were 75.6% less likely to enroll in a CS course in the future than freshmen. Juniors indicated that they were 76.4% less likely to enroll in a CS course in the future than freshmen. This implies that high schools need to offer CS courses more to freshmen than sophomores and juniors. In addition, earlier CS experience before high school such as elementary or middle school experiences is also a statistically significant factor. (Wald=4.367, $p = .037$). Students who had CS experiences before high school showed that they were 1.6 times more likely to take additional CS

courses in the future than students who did not. These variables are related to time and exposure. These results imply that students need to expose to CS at an early age.

Given that gender emerges as a significant determinant influencing future enrollment trends, it is imperative to conduct a thorough examination of the reasons influencing the decision to pursue additional CS courses by gender. Table 5 shows why students continue taking CS courses in the future. In evaluating the top six reasons to continue taking CS courses, both girls and boys responded “I enjoy learning CS” as the primary reason. They also responded that future career relevance is a significant reason. What is the most different between male and female students is the teacher factor. Girls ranked “I have a good CS teacher” as a more important reason (ranking it as the 2nd most important reason), while boys ranked the impact of their teacher as the fifth critical reason.

Table 6 shows why students stop taking CS courses in the future. The most common reason for not taking CS courses

Table 5 Responses to why students continue taking CS courses

Total	M-Rank	F-Rank	Responses
190	1	1	I enjoy learning computer science and/or programming.
133	2	2	I think computer science will help me get a good job in the future.
125	3	4	I find computer science courses challenging and interesting.
123	4	5	I think many jobs will require computer science knowledge.
100	5	2	I have a good computer science teacher.
97	6	6	I think computer science will help me have a high salary in the future.

for both genders was related to a future career in which students say “I don’t want to pursue a career in CS”. Another reason for not taking CS courses is that students find CS courses irrelevant to them. The next reason for not taking CS courses was the difficulty of the CS course.

Discussion

The aim of our empirical study is to examine current CS course experiences that high school students have and to identify what factors affect their future CS course enrollment. First, we investigated high school students’ positive and negative experiences of CS courses. Results showed that 85.7 % of responses illustrated having positive experiences within their high school CS courses, whereas 14.3 % of responses described having negative experiences. There are several reasons students demonstrated positive CS experiences. If students find CS class to be a meaningful curriculum and fun to learn, they have positive experiences. In addition, if students regard their teachers as knowledgeable or helpful, they have more positive experiences. Furthermore, relevance is the reason that affects students’ CS positive experiences. On the other hand, the biggest reason for the negative CS course experience was related to the curriculum mentioning that CS was difficult, boring, or not fun. Other reasons why students have negative CS experiences were that they found CS were irrelevant to them in their daily lives or future career, and teachers were not knowledgeable.

Next, we identified what factors influence students to take more CS courses. Students’ positive experiences were significantly important since these positive experiences foster them to further take CS courses. If the CS curriculum is enjoyable and interesting, it is relevant to them, and the

teacher is knowledgeable and helpful, students are more likely to take additional CS courses in the future again. Other than current positive experiences, some factors also affect future CS enrollment. We gathered demographic and background information to conduct logistic regression that enabled us to identify the factors influencing future CS enrollment. High school students’ previous CS experience, such as elementary or middle school experience, was statistically significant to predict future CS enrollment. Additionally, gender was also statistically significant to predict future CS enrollment, having a big discrepancy between male and female students in terms of taking more CS courses again.

Given these results, we suggest how to enhance students’ positive experiences toward CS courses and motivate them to pursue future CS enrollment. First, it is imperative to develop engaging, meaningful, and fun curricula that attract students’ interests and broaden their participation since most responses were associated with the curriculum. Student-centered pedagogy such as project-based learning and hands-on activities can effectively augment understanding and involvement in computing (Jayathirtha & Kafai, 2019; Jethwani et al., 2017; Yett et al., 2020). Examples of fun hands-on activities could be web and game design and physical computing activities such as e-textiles, Makey-Makey, and Circuit Playground. CS pedagogy can be also made fun and engaging by incorporating elements of gamification (Papastergiou, 2009; Stewart-Gardiner et al., 2013). When the CS class is fun and meaningful, students are more likely to actively get engaged in their learning. Consequently, this leads students to take more CS courses and broaden their participation in CS in the future.

The second suggestion is related to the teacher factor. A teacher is a critical factor that impacts both current CS experience and future CS enrollment for high school students. When teachers are more knowledgeable or helpful, students are willing

Table 6 Responses to why students stop taking CS courses

Total	M-Rank	F-Rank	Responses
72	1	1	I don't want to pursue a career in computer science.
72	1	1	I don't think computer science is relevant to me or my future.
54	3	3	Computer science is difficult for me to learn.
39	4	3	I don't feel like I belong in computer science classes.
29	5	5	I feel that computer science classes are boring.
28	6	5	Computer science isn't what I thought it was.

to have positive CS experiences and continue taking more CS classes. If teachers are not comfortable with the technology they are teaching, it is hard to foster students' learning (Ertmer & Ottenbreit-Leftwich, 2010). Thus, professional development for teachers is desirable to deepen teachers' CS knowledge and enhance their self-efficacy with technology and CS. Also, schools and states try to recruit more knowledgeable teachers.

The third suggestion is to make CS lessons relevant to high school students' daily lives and practical real-world applications. Within our survey, students responded that they had negative experiences when the class was not relevant to them. The relevance possesses the potential to motivate students to continue in CS (Alvarado & Dodds, 2010; Jones & Hite, 2020; McGee, et al., 2016). CS pedagogy should be authentic and meaningful to students' experiences, interests, and cultures. It is desirable that teachers shed light on the relevance since computing and technology are everywhere and closely connected to students' daily lives so that students can increase awareness of the relevance of CS. An example of this could include connecting with community experts and mentors to talk to the class about career opportunities and real-world examples of computing in an effort to expose students to CS-related careers and opportunities. The mentors and local experts can provide affirmative influences and exposure to CS for students.

To foster female students' participation in CS, one of the possible solutions is inclusive environments and affective elements such as support from classmates, teachers, and the community. Wang et al. (2015) highlighted that social encouragement was the leading factor in pursuing CS for female students. In addition, our data clearly showed that female students were more likely to take additional CS courses because of the teacher than male students were. It is imperative to have teachers who can influence positive impacts on female students to broaden their CS participation. Schools also need to ensure that they are actively encouraging girls to take CS courses for diverse and inclusive CS environments. One of our participants stated below why she wanted to take more CS courses and it can be a great answer to why we encourage female students to take diverse CS courses.

“While there are fewer students of my gender in the class, I wouldn't say I like that because it makes me feel special but I think it is important for women with a passion in STEM to pursue their interests to bring more diversity to the field.”

- Student ID 174-

Conclusions

This study was designed to examine the experiences of high school students in CS and the factors that influenced their decisions regarding future CS enrollment. Nevertheless,

there are a few limitations. While this study provides an initial overview of the perceptions that current high school students hold about CS, there needs additional information such as the relationships between teachers and students in specific CS courses, as well as the grade levels at which students of different genders commence their CS courses. Moreover, it is imperative that participants encompass a diverse representation of ethnic backgrounds to comprehensively examine the demographic influences on CS enrollment. This research was conducted exclusively within the state of Indiana. Consequently, the results from this study may not be generalizable to other contexts with varying demographics and cultural backgrounds. This research was a cross-sectional study focusing on a single academic year and we did not track whether the students continued to take additional CS courses in the subsequent academic year. To gain a more comprehensive understanding, it would be desirable to conduct a longitudinal study involving the same participants in future work.

Despite these limitations, our research has implications and significance for the field of CS education. We scrutinized students' specific and unique experiences within the CS courses with a large population of high school students. We identified what their positive and negative experiences were. Moreover, we have identified the factors that shaped these positive and negative experiences in their CS courses, which in turn may influence their decision to pursue further CS coursework. Understanding individual students' experiences and contexts can facilitate the design of more effective CS course environments, consequently enhancing students' participation and engagement. Furthermore, our study revealed gender-specific motivators for pursuing CS courses. Notably, female students seemed to be more influenced by their teachers, highlighting the need for knowledgeable instructors equipped with diverse and effective instructional strategies that are tailored to accommodate students' prior experiences. Additionally, fostering supportive classroom environments and interactive communities is recommended to promote a sense of belonging and equity for all students in CS.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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