Revisiting Why Students Drop CS1

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ABSTRACT

This paper describes a qualitative study of the factors that contribute to a student's decision to withdraw from CS1. Individual interviews were held with 18 students in a majors-focused CS1 at a large, research-intensive North American university, and results both validate and extend previous work on the experience of students who struggle in introductory computer science. In particular, our analysis confirms the complexity of the decision to drop, with students citing a combination of interrelated factors that contribute to the decision. Lack of time, combined with ineffective study strategies or with a prioritization of other courses, were the most commonly cited combinations of factors. Interestingly, when compared to the experience of students who chose to complete the course, there is evidence that students encounter a decision point when they realize they are or soon will be behind. Students who drop speak of focusing on other priorities or being unable to catch up, while students who complete speak of understanding the need to use new techniques for learning and increasing their efforts.

CCS Concepts

•Social and professional topics → Computing education; •Applied computing → Education;

Keywords

CS1; retention; dropping

1. INTRODUCTION

The experience of students enrolled in their first computer science course determines whether they continue to study computer science or leave to apply their talents in other fields. That first computer science course is often an introductory programming course (CS1), and this course often has a significant failure or non-completion rate, with pass rates estimated to be ~67% across institutions [1, 25]. As a result, studying the experience of students who fail to complete CS1 takes on particular importance.

This paper describes an interview-based study of the factors that contribute to a student's decision to withdraw from CS1. The work is inspired by, and extends, previous work by Kinnunen and Malmi on the experience of students who withdrew from CS1 [9] and our earlier contrasting work focusing on the experience of students who succeeded at CS1 [21]. Our focus here is on the confluence of factors that led to the final decision to withdraw from the course. In particular:

- What issues do students raise as primary and secondary factors influencing their decision to drop?
- How do the issues raised by students who dropped CS1 compare to the issues raised by students who successfully completed the course?

2. RELATED WORK

The identification of factors that contribute to success and retention in CS1 is a major area of interest in computing education research and, more broadly, in the STEM research community [17, 7]. In the STEM community, which has been heavily influenced by the seminal work of Tinto [22, 23], little evidence has been found of differences between students who choose to stay in STEM and those who leave except for motivation to study the subject [17]. Nevertheless, in computer science, significant effort has been spent on the search for individual factors that might influence the decision to remain in CS1, including the motivation to earn a high grade and expectations about workload [16, 15]; math grades, whether students play video games, and programming self-esteem [3]; lecture attendance and tendency to work alone [5]; program of study [8]; and learning approach goals [20].

Factors relating to community and belonging also contribute to the decision to remain in computer science. Biggers et al. found a perception, among students who chose to switch programs, that the field has little connection to the real world and its issues [4]. Lang et al. identified seven factors that affect retention in CS1 and categorized them as "gendered factors" (those that pertain specifically to retaining female students), "pedagogical factors" — including the curriculum and assessment methods, and "sequencing factors" — the position of the course in the program [12].

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The advantage conferred by prior experience is particularly well studied. Multiple groups [6, 18, 5, 8] have found that students with prior programming experience perform significantly better in CS1, but Ventura and Ramamurthy [24] described a course designed with an early emphasis on abstraction and modeling in which prior experience provided no advantage.

Furthermore, students believe that prior experience conveys an advantage, with some stating that it is the knowledge of what is required to succeed that is important [21]. Others have also studied expectations, with Rountree et al. suggesting that a student's expectation that hard work is necessary is an important predictor of success [16]. However, the actual amount of time spent studying may not be a factor [5]; the student's expectations are more important.

Kinnunen and Malmi's interview-based study is the most similar to the work in this paper [9]. Their work identifies lack of time and lack of motivation as the main reasons for non-CS students choosing to withdraw from a CS1 course. They also suggest that the drop decision is a complex one, where the primary factors are motivated by a set of other factors, including perceptions of the difficulty of the course, study habits and time management, or changes in goals. A follow up study [10] expanded on these results by exploring what topics were particularly difficult for students. The later work included both students who completed the course and students who dropped.

Kinnunen and Malmi's time and motivation themes [9] formed the basis for the first set of codes used to interpret the interviews in this study. To these, we added codes from other studies of retention including commitment to the discipline [17, 2, 27], academic performance [26, 2], and personal issues and stress [26, 2, 27].

3. METHODOLOGY

The study was performed on a large CS1 course at a multi-campus research-intensive North American institution. The course is required for all Computer Science majors, as well as for other programs like statistics. Students are not expected to have prior programming experience, but 40-60% of students in a term typically have some form of experience.

The study was run in fall 2015. Participants were solicited from two campuses at the university. Peak enrolment in CS1 on campus A was 1161 and on campus B was 733 students. One section on the campus A, with 252 students enrolled, was delivered in an online format, and the other sections were delivered using a face-to-face flipped format. On campus B, all sections were delivered using traditional lectures.

The course uses Python as its programming language. On campus A, students completed weekly exercises individually online, while on campus B, students completed weekly in-person labs that could be done alone or in pairs. All students were assigned three programming assignments. Some were to be completed individually (A1 on campus A, A1 and A2 on campus B), and the remainder could be completed in teams of two. Students also wrote midterm and final tests.

The term lasts twelve weeks. Students are allowed to drop courses as late as the last day that classes meet for lectures using a "late withdrawal." However, students are restricted to a small number of late withdrawals over their career, so most students drop before the regular "drop deadline," in the ninth week. There is a financial incentive to drop earlier, as well, as the amount of fee refunded decreases with time.

3.1 Data Collection

The investigators worked with the course instructors to obtain enrolment data. Every week, starting with the second week of the course, one of the investigators, who was not a course instructor, sent emails to the students who had dropped the course during that week, inviting them to participate in an interview for which they would be compensated financially. A reminder email followed a week later. A total of 327 students received an invitation.

Students who chose to respond to the invitation — 18 (5.5% of the students who dropped) — were interviewed by an investigator based at a different campus from that where the student was taking the course. This was done to minimize a chance of future interactions between the interviewers and the participants. Five participants were from campus A (4 from the online section) and 13 were from campus B.

We used semi-structured, open-ended interviews, which began with a general invitation to describe the student's experience in the course, and then, if necessary, followed with specific questions outlined in the interview plan in Appendix A. The interviews lasted between 8 and 45 minutes. If the interviewee consented, the interview was recorded and later transcribed. Otherwise, the interviewer took written notes.

3.2 Data Analysis

The investigators coded the anonymized and transcribed interviews using a grounded theory approach [14]. Beginning with the initial set of codes derived from related work [17, 26, 2, 27, 9], all four investigators independently coded the same interview, modifying the codes as necessary. They then met to discuss their results, identify overlaps, and update the codes. This process was repeated until the investigators determined that the codes had converged.

Then, using the final set of codes, the investigators reanalyzed all the interviews. Each interview was independently coded by two investigators, and the two sets of codes were merged by a third investigator. After all the interviews had been coded, the investigators met to identify common themes. This work began with each investigator manually analyzing an interview, and summarizing the main reason(s) for the student dropping the course. After merging and discussing these reasons, the set of themes in Section 4 emerged and were documented using quotes from the interviews.

3.3 Threats to Validity

Only the students who chose to respond to the invitation email participated in the study. There are several possible factors for selection bias. First, the responding students may have been more motivated by money or financial concerns ($20 compensation was offered for participation) than students who chose not to respond. Second, it may be that the students who are more social, more outgoing, more comfortable talking to professors were self-selected. Third, there is a possibility that students who struggle with English were less willing to participate in an interview, which could exclude a significantly large student group of our CS1 class. Finally, and most importantly, students who were still feeling uncomfortable about their course experience or their decision to drop the course were unlikely to volunteer. As a consequence, students who had a particularly negative experience may have been excluded from the study.

Some interviewees may have misrepresented their CS1 experiences or their view of their peers due to a personal

Table 1: Details of Interviewed Students

ID	Gender	Role of Course	Year of Study	Drop Week
A1	F	Required	3	5 (A1)
A2	F	Required	3	5 (A1)
A3	M	Elective	1	6 (Midterm)
A4	F	Elective	?	5 (A1)
A5	M	Elective	1	9 (Drop date)
B1	M	CS Major	1	6 (Midterm)
B2	F	CS Minor	3	5 (A1)
B3	M	Elective	2	8 (Drop date)
B4	M	CS Minor	3	6 (Midterm)
B5	M	CS Major	1	8 (A2)
B6	F	CS Major	2	12 (End)
B7	F	Elective	1	9 (Drop date)
B8	M	Required	1	9 (Drop date)
B9	F	Required	3	9 (Drop date)
B10	F	Required	2	6 (Refund date)
B11	M	CS Major	1	10 (2nd Midterm)
B12	F	Required	3	9 (A3 posted)
B13	F	Elective	5	8 (A2)

agenda or may have avoided issues, consciously or unconsciously, they found particularly unpleasant. For example, some interviewees may have been unwilling to admit putting an inadequate amount of work into the course or using inappropriate study behaviours. Finally, the investigators identified that some participants contradicted themselves during the interview, perhaps as they revised their recollections.

The interviews were structured such that, following a general invitation to describe the student's experience in the course, the investigators asked follow-up questions. It is therefore possible that the researchers' bias affected the content of the interviews. For example, the investigators specifically asked about prior programming experience. It is possible that other important issues were omitted from the interviews because of lack of corresponding follow-up questions.

4. OBSERVATIONS

This section describes the themes that emerged from the student interviews, illustrated using direct quotations. Table 1 contains details about the students interviewed.

4.1 Workload and Changing Priorities

A number of students in the study explained that they dropped CS1 because their priorities had shifted due to a change in their program of study. In many stories, the program change was from a non-CS field (such as mathematics) that required CS1 to a field where no CS was required. In others, the student opted not to pursue a CS minor.

On its own, a change of program is seldom the full reason for dropping CS1. After all, a huge number of students take CS1 as an elective.[1] Furthermore, most dropped early enough that their initial participation would not show up on their transcript but not early enough to get a full refund or to enroll in a replacement course. So, while students who changed their program may no longer *need* CS1 to graduate, the decision to drop would leave them short an elective course and require them to take a make-up course later.

CS1 is a lot of work

Investigating further, we see that for many students, the shift in program meant a shifting of priorities for allocating time. This is connected to the fact that most of these dropping students found that CS1 was a lot of work.

> **B10** It took so much time and the thing is I have other courses too and I couldn't compromise on all three or four other courses for my one course.

> **A4** The amount of work is unreasonable.

Too Much Work For an Elective

In particular, students who were taking CS1 as an elective were sometimes surprised at the amount of work. They expected that because this course was not their priority, they would be able to spend less time on it as an elective.

> **B4** it's not an easy course. It's not a bird course.

> **A5** But then, cause on this course I had to spend more time than actually studying for [courses in my major]. So that was getting in the way of getting those marks that are more important to me. This was an elective. Well after I just decided that I couldn't handle it any more so I dropped it.

Although these students could have enrolled in a CS0 course for non-majors with a short unit on introductory programming, they enrolled in CS1, alongside students intending to major in CS.

Which course to drop? CS1

While some students were clearly working hard and putting in considerable effort, others were not really working and were having trouble in general with the self-regulation and time-management required at university. One student explained that completing one of the three major CS1 programming assignments took four times as long as assignments in his other courses. But when probed, he said that it took 20 hours in total, which is longer than intended by the instructors. More surprising is that a major assignment in his other courses would only take five hours. Another student claimed that he had done all the work up until he dropped, but in the interview revealed that he considered attending the lectures and labs (with no preparation or follow-up) to constitute all the work. He later added that he knew he should follow the advice to practice with the programming language, but he hadn't done that. A third student stated that she "tried really hard" but then explained that she expected that she would need to pay attention in lectures, work during labs and then "go home and practice for like an hour at home or something like that." She detailed her participation in her non-CS courses as attending lectures and tutorials and not really doing any outside-of-class work. She found that she wasn't succeeding (in CS1 and some of her other classes) by only putting in this effort, but wasn't willing or able to put in more time.

Once students are struggling in all (or many) of their courses and feel that they can no longer manage a full load, CS1 seems to be the course of choice to drop – particularly if it is an elective, either from the beginning or as a result of a program change. Students are making rational decisions to focus on their other courses.

[1] One student discovered that CS1 would appear on her transcript but would not count for graduation because she had completed the maximum number of first-year courses.

> **B8** I was just comparing what I needed to do compared to all my other courses. What would be the best to drop, to sort of focus on other ones? And computer science was what I felt like, uh, it would require the most work.

> **B7** I was falling behind in like a majority of my courses then. If I didn't drop computer science [...], I think I wouldn't be able to juggle like all five of them. So, I chose to drop that and to try to catch up my other courses. [...] compared to all of my courses, [CS1] would be the worst to catch up.

4.2 Belief That Effort Leads to Results

When discussing study habits, students often mentioned the amount of time they spent on the course and the effort they put into learning. In some cases, students were able to correctly assess their understanding of the course material, but others misjudged how well they were doing in the course. Some students also expressed views on what was required to successfully complete the course, with some stating that more time or effort was needed.

Spending time, but not getting results

The students described a wide variety of approaches to studying, including reading the textbook, rewriting lecture notes by hand, watching videos, attending lectures by different instructors, and working on the labs in advance at home. In some cases, students spent time on ineffective study habits. Some students describe the effort they made and express dismay at not seeing results.

> **B6** [When I took the course] last year [...] it was like the same thing. I tried really hard. I feel like I tried more last year and then this year I was just so frustrated I was like I don't know why I'm not getting this. And then I stopped.

> **B3** Yes, [assignment one] took a lot of time. I divided it into four days, and I worked five hours a day. And it was really frustrating, because I couldn't get to the end.

> **B10** I was putting in at least two to three hours every day. Because, like the stress was getting to me. Like I've always had everything go right for me or even if something wasn't, I would make it right. But this was the only course where I found I couldn't make it right no matter how much I tried.

Not accurately assessing understanding

Unfortunately, students did not always realize that the effort they were making was not necessarily improving their understanding of the course material. In some cases, it took a major wake-up call, such as being unable to make progress on some coursework or performing poorly on a test, for students to realize that they did not have a strong grasp of the material.

> **A4** I was very committed and I was putting in a lot of hours. And I was doing very well. Until the assignment came out. It was very confusing. I did not even know how to begin coding it. [...] I was putting in so many hours, doing all the videos and exercises, and yet I had no idea how to even start the assignment.

> **B13** I got a 100% on [the first assignment]. [...] And I enjoyed it. Um, then the test came. I felt ... very prepared. [...] And when the test came, I was I felt completely lost. Even questions which were marked as easy I didn't know how to do, and the test, I ended up getting a 34% or something, which was very ... big ... a huge surprise to me.

Belief that more effort or time was needed

When students realized they were struggling, some quickly dropped the course, but others tried to find ways to recover. During the interviews, some students reflected on what they needed to do to succeed or what they plan to do when they retake the course, and they occasionally mentioned needing to put in more time or effort:

> **B11** I did bad on the first test. I thought, "if I work harder, I'll do better on the second test."
>
> **B3** If I were to catch up, I think I needed to spend more time, but I think computer science, learning how to program, I needed to put more time and ... compared to my other courses.

4.3 Falling Behind

Fourteen students spoke about falling behind and being unable to catch up again. A minority felt that they were falling behind throughout the course.

> **A5** when I understood it I was already behind on what I had to learn next because it builds on. [...] If we had a one week to learn it, I learned it in like seven days, like ten days, fifteen days. It just took longer for me to learn it and I just kept falling behind and behind and behind.

But most students felt they were doing well until they were confronted by an assignment or topic that made them realize they were not prepared to complete course work at the expected level. Some students did not understand they were behind until they received an assignment mark.

> **interviewer** What was your assignment mark?
> **B9** Eight [pause] percent.
> So I saw that and I was like, ok, I am not understanding a thing and I need to practice – like from the very beginning basically.

But most students identified a gap once they saw what was expected in the assignment.

> **A2** It was like just following the module but then the first assignment came and I was like wow, this is really hard. And probably I didn't study enough or I need to go back and actually go through the material and look up notes.

Being confronted by a difficult assessment is stressful, in particular because it not only reflects poor academic progress, but it also discounts all the time and effort previously invested in the course.

> **A4** And I was doing very well. Until the assignment came out. ... I was putting in so many hours, doing all the videos and exercises, and yet I had no idea how to even start the assignment. This is when I decided to drop.

The pressure of completing an assessment in time was an issue even if a student committed to completing it. If a student falls behind, they may not have enough time to pick up the necessary skills before an assignment due date.

> **A3** if you fumbled on a step, you weren't able to umm ... to get back up before the time. Before everything was due.

When a student falls behind, they struggle with the added burden of trying to learn the following material with less support. A student who falls behind cannot benefit from or contribute to the in-class exercises and labs until they are in a position to work on new material.

> **B9** I was gonna try to continue to attend the lectures but it's just too fast for me. I'm not even understanding what's going on right now ... I might as well just start from scratch and just remember whatever I can.

> **B3** ... the catching up was the hard part. From what I saw of it, if I had attended the first lab, it would have lead to the second lab and then to the third lab, and it would have worked fine. 'cause ... the program is set there. I just need to be there.

Several students felt like they were working alone once they needed to catch up. As a result, because of the high cost of falling behind, getting support as soon as you have a problem is important.

While support was available, nine students complained that the amount of support was insufficient:

> **B7** My TA was very busy and he couldn't really help me too much.

> **B11** The TA tried to explain but I needed more help.

One noted that they didn't access available supports:

> **B4** It's better to go get help from someone rather than just sitting there [...] Yah, but I didn't do that.

In the next quote, the student pauses and then fades away at a loss for words. This reflects the feeling of hopelessness of students who are lost, without support, and with nowhere to turn for help.

> **A2** I think ... the most important thing for me is having enough support on it. [...] Even if you're good at it, you're going to have trouble. There isn't a resource or a person you can go to, then that ... then ...

4.4 Unforgiving Level of Detail

Three students specifically noted that the amount of important details in computer science impeded their ability to make progress.

> **B1** Programming is so technical. There is only one way to do things that can be correct. It is so picky – getting the brackets and the colons all perfect. So many technicalities. And it was so severe that I couldn't even get started on the problems.

The students report that the level of detail – and the study behaviours and attitudes required to handle it – differs from other fields they have studied but resembles mathematics. One student, speaking of the comparison between catching up in a CS course and catching up in other courses, said:

> **B3** [The work in my other courses is] just reading and questions. Answering questions. It's pretty straightforward, I guess. Computer science, just like mathematics. You have to put in work, go into problem solving.

As a result, one student reported appreciating the details highlighted in the online programming resources for the course.

> **A2** It's really simple, once you figure it out, but step-by-step instructions and instructions about what to pay attention to – and what to ignore – are really important.

4.5 Prior Programming Experience

Eight interviewees reported that lack of prior programming experience was a major factor in making a decision to drop the course. All eight believed that the majority of students in class had prior experience and that students with prior experience had a significant advantage over novice programmers.

> **B12** On the first day of class, she [the instructor] asked "Which of you knows how to program?" and everyone raised their hand.

> **B10** I felt like almost everyone knew everything that they were doing; [. . .] like people who were sitting next to me, they kept on doing stuff and I was just looking at them and I was like, "How did you get it done in ten minutes?". And they were like, "We have experience — programming experience." [. . .] I can't afford to take so much time when everyone around me is taking ten minutes.

> **A5** . . . some people that didn't have any experience they found it really hard but people that actually took programming in high school, like at my high school, were actually able to keep up with the work and it's not that hard for them. I feel like just a little bit of knowledge would have helped like a lot.

Two students reported that the instructor asked about the experience level of the course and then explicitly increased the pace of the course because many of the students had experience.

> **B10** I think one of the profs even said "who has programming experience?" and a lot of people like 90% of the class raised their hands and they were like, "ok we're gonna go at a faster pace." Something like that.

Being in the minority can cause stress, feelings of isolation and intimidation.

> **B4** If you did comp sci before like at least something before, then it's easy for you. [...] Otherwise, you think it's a lot of pressure.

> **B10** Before I started the class, um, I had no experience, I was a little freaked out about it. [. . . and later . . .] Sometimes even during classes, we feel like we're gonna ask something really stupid. We can't keep asking stupid questions, right?

One student suggested that prior programming experience was *necessary* for successful completion of the course:

> **B1** . . . I was poking around on some online forum and I read stuff about this course that said it wasn't really an intro course. People were saying that it was more like a 2nd-year course and you had to have programming experience to do it.

Another student, who had dropped the course and was planning to retake it in the future, reported that he was going to first take CS0 in order to get some programming experience before re-taking CS1.

> **A5** I never took um computer science in high school so I think it was a little, a little harder for me and I should've done [CS0] [. . .] and I think that would have been a better start [pause] for me. [. . .] If I can take [CS0] before I guess, so then I have a better prior knowledge understanding going into it.

Interestingly, in response to a question about what we could do to improve the interviewee's experience in the course, one student suggested streaming:

> **B10** . . . if they had different lectures for people with programming experience and people with no programming experience.

4.6 Relying on Others

A common scenario (five interviewees) involves a student becoming dependent on someone else, either inside or outside of the course, to complete course work. As the term progresses, the student realizes that this has a negative effect on her learning, but decides it is too late to catch up with course material.

> **B11** I was attending all the labs. I . . . got the marks with the help of other students. [. . .] But then when we did dictionaries and classes and lists, it got a lot harder. I started to fall behind and I didn't understand.

> **B9** I relied a lot on other students for help. I felt like everyone around me knew what to do and I didn't know what to do so. They would help me and stuff like that, but I felt like . . . or when it was time to pair up with people, my partner did a lot of the work or practically all of the work. So I was like . . . It wasn't too good for my learning experience because I wasn't able to do hands-on myself and . . . come up with these codes myself.

> **B12** I made some friends with people in my lab. I asked them if I had questions. [. . .] I didn't want to rely on other people to get through the class.

Another student explained that she felt she relied too heavily on the TAs to complete the in-class exercises.

> **A3** It was so guided that when you're asked to do it alone afterwards, it's just ... it's a different thing altogether. It's so guided when you're doing it in class. You have the TAs walking around, and if they see you do anything wrong, they're instantly there to correct it for you. And then all of a sudden, not to have that [...], when you're doing it ... it's a different mindset.

4.7 Social Groups

A variety of social factors can also impact students and shape their experiences in CS1. For some students, the encouragement of friends or family influenced their decision to enroll in CS1 in the first place:

> **B13** I had [...] more elective course to take, so I decided to take this course because uh my boyfriend actually graduated from this program, and he keeps saying how awesome it is and he keeps comparing it with management.
>
> **B3** I usually like computers, and my friend actually works with Java. It seemed pretty interesting.

Once enrolled in the course, the social group that students establish or the lack of social network, impacts their course experiences. Some students describe isolation or missing social groups within the course, with some emphasizing that social isolation can be particularly problematic in the online section.

> **A3** I didn't have any peers.
>
> **A2** In online courses, you don't really communicate with your prof. You don't really communicate with your peer that much.
>
> **B6** [...] it started to get harder and harder and that's where I had problems and I was also doing it online and I couldn't sometimes I couldn't find people to talk to if I had questions.

One student describes feeling left out of the social groups, because she was more senior than many of her classmates.

> **B13** Also, I was a little disappointed because I couldn't get the full teamwork experience there, most of the students were first year in their program and they ... they were looking at me a little weird. At least, the group of people. They were like, "You're not even in the program, you're in your last year, why you want to take this?"

But not all students felt alone. Some students managed to form social groups or find peers to work with, which seems to have been a positive aspect of their experience in the course.

> **A3** I did find people in that class I could talk to. It was pretty good. That was the main reason I stuck in so long. I had made some pretty good friends in that class.
>
> **B4** I did talk to a lot of friends in that class. The friend I used to work with was a first-year student. Like most of them are first-year students in my lab and I spoke to them.

Another way that students are influenced by social factors is through their self-identity. Some students express doubt in their ability to learn programming and others express beliefs that some students are better at computer programming than others for a variety of reasons, including gender.

> **A4** I am not a computer person. But I think it is a fascinating subject and in today's world everybody should learn to code.
>
> **B1** It wasn't the teacher or the pace – it just wasn't for me.
>
> **A2** I think guys and girls they're ... okay, first of all like things that we're good at are different, I think that girls are good at ... I don't know just like, I find obviously, talking. Girls can describe more. If you ask a guy, he'll say I don't know or I guess. That kind of thing. But with technical stuff, they're really good at it. Like, even my boyfriend, even if he hasn't learned it before.

4.8 Dropping is Acceptable

For some students, dropping CS1 seems to be viewed as a common, acceptable practice. Several of the students interviewed had enrolled in the course before and about half had plans to re-enroll in a future offering. Some students mention friends and classmates who also dropped the course, sometimes multiple times.

> **B12** I have a friend who is doing a stats major, too. She's dropped it three times.

In some cases, the students seem to point out others who dropped in order to justify or normalize their own decisions to drop.

> **A2** ...my boyfriend is in the same course and he dropped as well. ...if he dropped it because he thought it was overwhelming too and then I was like, if you think it's hard, too, then I'm not even going to [laughs].
>
> **B10** I felt pretty bad about dropping the course and I did 'til like last week, but then my other friend, this is the second time that she's taking her course and she dropped it yesterday and she's like, "I can't do it." Even though she has some experience too. So then, now I don't regret it at all and I don't even feel bad about it.

The frequency with which we heard this viewpoint, however, was particularly vulnerable to subject pool bias. Students who feel that dropping is **not** acceptable and remain uncomfortable or embarrassed about their situation are unlikely to volunteer to speak about their experience.

Free Alternatives are Available

The availability of Massive Open Online Courses (MOOCs) and other online resources as alternatives to CS1 may also mitigate the consequences of dropping the course, particularly for those taking the course as an elective. One student commented that she would use Code Academy to learn on her own to "satisfy her curiosity" until she can retake the course. She also expresses some dissatisfaction with aspects of the course and views the availability of online resources as a reasonable alternative.

> **B2** and I thought ... uh I'm paying for this when I can just get the hands-on experience online, as well. And everyone I seemed to talk to said I don't know why we even have textbooks in the bookstore for this when everything is online. Learn everything online and that kind of pushed me ... I'll do it myself online.

When another student was asked whether she would consider retaking the course, she talked about learning using online resources and working at her own pace.

> **B13** What I've already started doing is signing up for courses on Coursera, ... there was a Python course I was planning to take. So, I'm going to take this one and also since the material is all available on the website, I am actually planning to continue learning it second semester, just on my own pace.

5. DISCUSSION

5.1 Comparison to Kinnunen and Malmi

One decade ago, in 2006, Kinnunen and Malmi completed a survey and interview-based study investigating the reasons that non-majors cited when dropping CS1 [9]. They identified the lack of both time and motivation as the primary reasons for non-majors dropping the course, but also noted that each decision to drop was motivated by a set of secondary factors, including the perceived course difficulty and low comfort level with the material, issues with study habits and time management, and changes in major or career goals.

Our work was partially motivated by a desire to investigate their findings in a different context. Like their study, our investigation is based in a relatively large CS1 course. However, student motivation to complete the course may differ due to admission policy and financial aid differences.

In comparison to the course studied by Kinnunen and Malmi, a majority of our CS1 students expect to enter a CS program. However, our university does not admit students into the program directly. Admission into the program is based on performance in first year computer science, making CS1 important to many students. That being said, the majority of students interviewed were not in this group. Some needed CS1 for another program, like mathematics, and others were interested in a minor involving CS courses.

Expectations on graduation time also differ in Finland and our North American context. In Canada, students pay a significant fraction of their educational costs. As a result, they may face financial pressures and often operate under the expectation that they graduate in a "normal" amount of time. Nevertheless, we heard no explicit mention of financial stress, though several students noted that a CS minor was not possible due to a desire to graduate on time.

Despite the differing contexts, our results confirm several of Kinnunen and Malmi's key findings. Like them, we identify lack of time and lack of motivation as key reasons for dropping a course. We also found evidence of the complex nature of the decision to drop the course, with students mentioning multiple, interrelated factors that influenced the decision to withdraw. In particular, many of our students identified a lack of time combined with a desire to perform well in courses that they prioritized due to program requirements or career goals. These students made a rational, well-informed decision to drop the course after considering the workload requirements of CS1 and their preference to focus on — and obtain good grades in — their major program of study.

Study behaviours and time management also emerged as themes, though the focus of student comments differs from Kinnunen and Malmi's work. While many students stated they were spending far more time than expected, as the Finnish students did, our students also stressed that the type of work they were doing — or failed to do — was important. Many expressed surprise or dismay that techniques that worked in other courses failed to work in CS1, with some suggesting that they believe CS requires a different approach involving more hands-on practice and, in one student's words, "fiddling." About half of our students also expressed frustration at a lack of support, but that frustration was often qualified by a desire that the support be available at the right time. Even when students felt that the quality of materials and level of support was appropriate, the unavailability of assistance at the instant they needed it increased study time and frustration.

Our results also suggest differences that may stem from context. For example, no students discussed plagiarism as a reason for dropping, but that is a result of local policies. Our university does not allow students who have been penalized for a violation of academic integrity to drop the course in which the violation occurred. More significantly, many of our students discussed concerns about the pace of the course and stated a belief that if you fell behind, it would not be possible to catch up. While the latter idea is related to the dependencies that exist between topics in a programming course, the lack of time to catch up is a function of the pace of our course and our relatively short semesters.

5.2 Comparison to Students who Persisted

In [21], we explored the effects of prior programming experience (PE) on the CS1 experience from the student perspective. We surveyed and interviewed students to gain insight on the effects that PE has on peer interactions and to learn about students' beliefs related to PE and course outcomes. Although we attempted to interview students who had dropped the course, only students who successfully completed the course participated. The current study, which focuses on students who dropped, contains a number of observations that provide support for our previous conclusions.

Prior Experience as an Advantage: Students interviewed for the current study also believed that students without PE are at a disadvantage. These beliefs are strongly held. Although students in [21] reported that it was possible to succeed without PE, one student in the current study suggested that PE is necessary in order to successfully complete the course. Some students went so far as to prepare for the course in advance to gain experience.

We also saw widespread belief that the majority of students in the course had experience, reinforcing the perception of students who dropped that they were at a significant disadvantage as compared to the majority in the course. Perhaps as a result, among students who dropped and plan to retake, several report that they feel the need to get experience before retaking the course, with some staying in the course after making the decision to drop solely to get experience and others planning to use online resources.

Problems with Partnerships: As in [21], in this study we also found that unequal partnerships prove problematic for novice programmers. In the present study, five students describe becoming dependent on others to complete course work. The reliance on others who had a stronger grasp of the material contributed to those students falling behind and eventually dropping.

The Decision to Persist: In both studies, we report on students who have a "wake-up call" where they do poorly on or struggle to complete course work and then face a decision point. Interestingly, in [21], these wake-up calls were turning points where the students changed their behaviour. Many made this course a priority and placed more time on it. Others changed how they approached the course, putting a different form of effort into the course. Conversely, in the present study, many students saw that additional effort or a different approach was required but chose to prioritize another course. Others expressed frustration because of the time and effort they were already investing.

5.3 Self-Assessment and Expectations

Many students who spoke with us had trouble evaluating their understanding or mastery of the material as the course progressed. Although the instructors designed the course to provide students with regular feedback, this feedback was often based on the eventual completion of a set of small tasks. Many of these tasks were intended as learning mechanisms, rather than summative assessment tools, and consequently, students were invited to work with partners and were allowed multiple opportunities to submit and receive auto-tested results.

While intended to provide feedback, these practices confused some students who conflated high marks with conceptual mastery of the material. For example, some students grew to rely on partners in lab and didn't discover that they were unable to operate on their own until it came time to apply course concepts on the midterm test. While the coding exercises performed in labs, in lecture, and online mirror the activities we expect students to complete on tests, having partners and frequent help from TAs, while important for facilitating the process of learning, can make it difficult for students to determine if they are able to complete these tasks independently. Students need to be reminded of the environment in which they will be assessed and given opportunities to evaluate themselves in this environment.

Similarly, the ability to submit exercises multiple times can facilitate a student completing the exercise without truly understanding what is occurring. Several students reported completing the frequent, small auto-tested exercises after many attempts (and, we suspect, guesses) and believed they had fully grasped the material for the course. These students were surprised that they were unable to even start the larger assignments and would have benefited from a reminder that understanding is more important than completing the assigned work for marks and that high grades do not necessarily indicate mastery.

The mismatch between the formatively-oriented exercises and larger programming assignments may also indicate a problem with the scaffolding in the course or, more seriously, a misalignment between the assessments and learning goals. Anderson and Krathwohl's revised Bloom's taxonomy [11] provides a useful lens for exploring this idea. Assessments in the form of multiple-choice word problems test recognition or recall (at the *knowledge or comprehension* levels of Bloom's taxonomy). In our course, these types of problems are frequently used early in the learning process in the form of reading comprehension questions. However, the primary learning goal for the course requires that students write programs. This requires *application* of a particular concept, a more difficult task in the taxonomy. As a result, we next ask students to fill in code to solve specific problems in both labs and online sets of exercises. However, the programming assignments require more: the ability to discern what is needed (from a problem description) and to combine multiple pieces of code to solve the problem. These assignments might be at the *synthesis* level, and the jumps from recall to application and from application to synthesis were too large for many students in our study. This suggests that insufficient scaffolding is in place or, as Luxton-Reilly has proposed, that simply too much is expected in too little time [13].

Finally, some students reported that CS1 was unlike many of their other courses and they struggled to succeed when their usual study techniques such as revising lecture notes were ineffective. These students were discovering that most of the summative assessments in CS1 are at the application level or higher on Bloom's taxonomy and require more than simple recall or basic comprehension [19]. In our particular CS1 implementation, the weekly formative assessments are typically at the knowledge and comprehension levels, but almost all the marks contributing to the final course grade are at least at the implementation level and many are at the synthesis level. Students need regular opportunities to self-assess at these levels and need to be told (and reminded) that mastery at the knowledge or comprehension level will not be sufficient to pass the course.

6. CONCLUSIONS

The decision to withdraw from a course is complex and is based, ultimately, on a set of interrelated factors. As noted in previous studies [9], lack of time is the key factor, but the decision that there is not enough time for CS1 is based on the relative importance of CS compared to other courses (or the student's future plans) and the effectiveness of the study strategies employed. The students we interviewed described, for the most part, rational decisions to prioritize and to spend time effectively in pursuit of their goals. This finding echoes findings in the STEM community that the main difference between students who stay and students who leave is intrinsic motivation to study the subject [17].

Besides confirming previous work on the struggles of students who drop CS1, a major contribution of this work is the contrast drawn between students who succeed and those who fail. In our earlier study focusing on prior experience, students characterized experience as helpful because it prepared them to spend the time and effort required. Students who succeed and those who drop both encounter situations that force the realization that they do not understand the material or have fallen behind. At that point, they make a choice. Students who drop focus on other priorities or, alternately and less commonly, speak of being unable to catch up despite the time they put into the course. Students who succeed speak of understanding the need for trial and error and the time that requires. An intervention or the provision of support at this point, if it can be identified, may be effective at increasing retention.

The forcing point — the situation where students realize they have fallen behind — can be exacerbated by a misalignment of assessments with learning goals or communicated expectations. In assignments, we expect students to be able to write programs from a specification — an application-level task — but students may expect to work at the level of knowledge recall. This expectation may be reinforced by early assessments, such as reading comprehension questions or the practice questions in labs, which provide full credit for recall and understanding tasks. If our expectations are reasonable [13], more scaffolding may help students understand the level at which they are expected to work.

In conclusion, we call for instructors to be more aware of the decisions that students are making when they balance the demands of CS1 with their other courses. The decision to drop is influenced by individual priorities, study behaviours, the availability of support at critical points, and (mis-)perceptions of the nature of the effort required to succeed in the course. While the first factor is not within our control, we have the ability to improve retention in CS1 by provisioning support at critical points in the term, clearly and repeatedly demonstrating expectations and effective study behaviours, designing assessments at the expected level and providing appropriate feedback.

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APPENDIX

A. INTERVIEW PLAN

Pre-Interview

1. Greet the student.
2. Provide a paper copy of the information sheet and consent form. Ask the student to review both documents and answer any questions that arise.
3. Confirm that the student is willing to provide consent.

   Yes: Write the student's study ID on the consent form.

   No: Terminate the interview.
4. Ask if the student would be comfortable with the interview being recorded.

   Yes: Turn on audio recorder, state the student's study ID, and repeat that the student has granted permission to record the interview.

   No: Record the student's study ID in your notes.
5. Reiterate that the student can choose to not answer any question or to terminate the interview at any time.

Interview

Begin with the grand tour question:

Could you describe your experience in CS1 this semester?

Reminders:

- Focus on the goal: to identify factors the student perceives as leading to the decision to drop the course.
- Ask follow-up questions (that do not presume the answer) after the student has finished relating her thoughts. Allow sufficient time for the student to fully relate her experiences.
- Remember that the student may be uncomfortable recalling or relating his experience. Be supportive, and do not continue a line of discussion if it is causing the student visible discomfort.

After exploring any issues raised by the student, review the following questions and ask any that were not answered naturally during the interview:

- Reasons for enrolling
  - *Why did you enrol in CS1?*
  - *At the beginning of the term, were you pursuing or considering a CS program?*
  - *Are you currently considering a CS program?*
  - *Do you intend to enroll in CS1 in the future?*
- Academic preparation
  - *How many* ***credits*** *have you completed?*
  - *Do you have any prior experience programming?*
- Dropping
  - *When did you stop actively participating – attending lectures, doing homework – in the course?*
  - *Could you discuss the factors that lead to your decision to drop the course?*
  - *What would have lead you to remain in the course?*

Post-Interview

1. Thank the student. Remind her that she may withdraw from the study at any point until the end of the term by contacting you.
2. Compensate ($20) the student for the interview.