“It Depends on Whether or Not I’m Lucky”: How Students in an Introductory Programming Course Discover, Select, and Assess the Utility of Web-Based Resources

David Wong-Aitken
Simon Fraser University
Burnaby, Canada
drw2@sfu.ca

Diana Cukierman
Simon Fraser University
Burnaby, Canada
diana@cs.sfu.ca

Parmit K. Chilana
Simon Fraser University
Burnaby, Canada
pchilana@cs.sfu.ca

ABSTRACT

University-level introductory programming courses (e.g., CS1) offer a structured and formal approach for learning programming where instructors design their own curriculum and materials to help students learn difficult concepts. But, there are a myriad of free resources increasingly available online for learning programming that university students can easily access at their fingertips. In this paper, we investigate to what extent students in CS1 make use of resources curated by their instructor vs. online resources that they locate on their own. We conducted surveys and interviews in two consecutive CS1-equivalent classes at a large North-American university and explored how students made selections and assessed the relevance and utility of web-based resources. We observed that students had a strong desire for quick answers and looked for ‘exact’ matches for their queries in forums rather than consulting videos or other resources that provide higher level explanations more suitable for novices. However, given that these students had a limited vocabulary related to CS1 topics, they struggled in locating the desired information and relied on shallow trial-and-error processes without a clear strategy or self-reflection. Interestingly, despite the lack of perceived success, students still considered their pursuit of online resources as more convenient and less costly than asking for help. Our main contribution is in presenting insights about CS1 students’ motivations and behaviours in using web-based resources on their own. We reflect on these findings by drawing upon theories from learning sciences and information sciences.

CCS CONCEPTS

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

KEYWORDS

learning strategies, online resources, introductory programming

ACM Reference Format:

David Wong-Aitken, Diana Cukierman, and Parmit K. Chilana. 2022. “It Depends on Whether or Not I’m Lucky”: How Students in an Introductory Programming Course Discover, Select, and Assess the Utility of Web-Based Resources. In *Proceedings of the 27th ACM Conference on Innovation and Technology in Computer Science Education Vol 1 (ITiCSE 2022), July 8–13, 2022, Dublin, Ireland*. ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3502718.3524751

ITiCSE 2022, July 8–13, 2022, Dublin, Ireland

ACM ISBN 978-1-4503-9201-3/22/07…$15.00
https://doi.org/10.1145/3502718.3524751

1 INTRODUCTION

Learning programming for the first time is a challenging task for most students. Instructors of university-level introductory programming courses (e.g., CS1) are continually improving their lesson plans and selecting high-quality resources to help students achieve the intended learning goals [31]. In addition to innovating on their instructional materials (e.g., course notes and slides), many instructors are also integrating a variety of web-based resources [18, 35], such as online videos [13] and even interactive tutorials and textbooks [15, 28]. These instructors expect that their students will take advantage of these curated resources to better understand complex concepts and will follow the instructors’ designed learning path for ultimate success [21].

For students learning programming, there is the potential to also access countless free online resources (e.g., online books, articles, tutorials, videos) related to a myriad of programming-related topics [9, 40]. Moreover, there are several online communities of programmers actively asking questions and providing answers and sharing code examples in Q&A collaborative forums, such as *StackOverflow* [11]. Many instructors have the intuition that CS students are frequently accessing such online resources [19] and university students, in general, are increasingly relying on the web for their information needs [9, 39]. But, we lack a systematic understanding of how students who are new to programming discover and decide to seek online resources on their own.

In this paper, we use a case study approach to investigate how students enrolled in CS1-equivalent classes at a large North-American university make use of resources curated by their instructor vs online resources that students locate on their own. We conducted two large surveys (N=176) and in-depth interviews (N=13) with first-year programming students to capture their different perspectives and perceptions. We focused on what motivates students to look for new resources, how they make their selections, and how they assess the relevance and utility of different resources.

Our key findings indicate that although the majority of students were regularly using the materials provided by the instructor, almost all of our participants frequently tried to search for external resources on their own. In particular, they desired to find resources that contained an ‘exact’ match for their queries. Since these students were still grasping the basics of programming and had a

Table 1: Type of resource and its classification. Internal is any resource that is provided or suggested by the course instructor, external is any resource that students look on their own.

Resource	Description
Internal	Instructor's notes or course slides
	Help from teaching assistant (TA) or instructor
	Course textbook (e.g., interactive Runestone book)
	Course-specific Q&A forum (e.g., *Piazza*)
External	Other printed books or e-books
	Online video channels (e.g. *YouTube*)
	Python or programming-related web pages
	Q&A forums (eg. *StackOverflow*)

limited vocabulary, they found it less helpful to consult resources with conceptual explanations. Most participants admitted that they resorted to shallow trial-and-error strategies [38] and tried different queries in search engines in hopes of looking through as many resources as possible, but were not always successful. Still, they rarely reflected on their strategies or changed their path, even though many realized that they were wasting time with little to no gain. Interestingly, this behaviour was self-enforced: even with the lack of perceived success, most participants considered looking for online resources on their own as more convenient and fruitful and less costly than asking for help or learning the underlying concepts.

Our main contribution is in presenting insights about CS1 students' motivations and behaviours in using web-based resources on their own, as a supplement to the instructor-curated resources. We reflect on these findings using learning and information science theories, analyzing similarities with information-seeking behaviours and preferences exhibited by professional programmers. We also discuss implications for future research to help students, instructors, and the CS Education community in general.

2 STUDY METHOD

To tackle our key research question about understanding how students in CS1 make use of different resources as part of their learning, we used a descriptive case study approach, combining insights from in-class surveys and follow-up interviews.

2.1 Research Site

We recruited participants exclusively from an introductory programming course offered in the CS department of a large university in North America. This course was offered fully remotely for the first time because of the COVID-19 pandemic. This course was open to undergraduates from any major and can be considered equivalent to CS1. The core programming language taught was Python and the course lasted 13 weeks. As explained below in our procedure, we first conducted a survey (S1) in summer 2020 which had a single section of CS1 (with 200 students) and later we conducted the second survey (S2) in the fall 2020 offering of CS1 which had 4 sections taught by 4 different instructors (with 669 students).

In both cases, the course was delivered using a combination of the Canvas LMS, Blackboard Collaborate, and synchronous Zoom sessions three times a week. Depending on the instructor, slides were published before every class or immediately after. Students had suggested readings for every class, mainly from the online interactive textbook on Python from Runestone [15, 28]. In the fall, the four sections were coordinated closely: they all used the same textbook, assignments and tests, and had one unique course website. In both the summer and fall offerings, the students worked on a significant group project at the end of the semester. Almost every week students were provided with assignments and quizzes; some were intended as practice, some for course points. Questions and exercises were created by the instructors, based on materials seen in class and in the required interactive textbook.

Internal vs. External Resources: We categorized the resources that students described using for their learning in two groups. Any resource that was provided or suggested by the course instructor or TA was classified as an *internal resource*. Any resource that the students looked up on their own was classified as an *external resource*. See Table 1 for examples of both types of resources.

2.2 Study Procedure and Instruments

SURVEY 1 ("S1"): The S1 questionnaire consisted of 27 questions with 24 closed-ended questions and 3 open-ended ones. This survey was conducted in summer 2020 (weeks 8 to 12). This was the first term that this course was offered in a fully remote format due to the COVID-19 pandemic. The questions were divided into four groups: basic demographics and prior programming experience, resource preferences for learning, learning difficulties and strategies to cope with them, and any self-monitoring strategies when learning through online courses. The instructor offered minimal points for participating (0.5%) and a $50 amazon gift card raffle was offered as opt-in survey incentive. The survey was anonymous and the instructor did not participate in the research nor have knowledge of who participated until the end of the course. We obtained 84 completed surveys out of 200 (42.0% response rate). Demographics are summarized in Table 2. Survey respondents optionally could also indicate if they wanted to participate in a follow-up interview.

INTERVIEWS: To probe further into students' experiences with programming resources, we carried out semi-structured interviews with a subset of the S1 respondents. We asked interviewees about their preferences for learning resources and strategies, perceived usefulness and pros/cons of internal and external resources, reflections on how they monitored their time and progress, and how they sought help. We invited all respondents from S1 who agreed to do a follow-up interview and were able to interview the first 13 (8F/5M) students. The interviews were conducted in summer 2020 (Table 2). We offered a $15 Amazon gift card to each participant. Each interview lasted 45 minutes on average and was carried out using the *Zoom* video conferencing tool. With permission of participants, we audio-recorded and transcribed interviews. Because the data from the interviews was not linked to the responses from S1, we again collected interviewees' demographic data via a questionnaire.

SURVEY 2 ("S2"): After analyzing data from survey 1 and the interviews, we wanted to further investigate about the prevalence of insights that we saw emerging, especially related to how students were relying on external resources and managing their time. This was also important given some of the variations in CS1 offerings at

Table 2: Demographics data from our participants

	Survey 1	Interviews	Survey 2
Term	Summer 2020	Summer 2020	Fall 2020
N	84	13	92
Male	50.0%	5	57.1%
Female	47.6%	8	40.7 %
Non-disclosed gender	2.4%	0	1.1%
CS Major	9.5%	0	44.9%
Non-CS Major	90.5%	13	55.1%

the university across different terms and instructors. We decided to conduct S2 with a different cohort of CS1 students in fall 2020 (weeks 8 to 12). Building on S1, we asked additional questions in S2 about strategies for locating external resources, usefulness of different resource types, and challenges in accessing and learning from external resources. There were 26 questions (23 closed-ended and 3 open-ended). The survey responses were anonymous and not linked to any bonus points this time due to logistical issues across different sections. We did still offer a $50 Amazon gift card raffle for participants. We obtained 92 completed surveys out of 669 (13.8% response rate). Demographics are summarized in Table 2.

2.3 Analysis and presentation of results

For the closed-ended questions in S1 and S2, we looked for general trends using descriptive statistics. We analyzed the transcripts from the interviews and the open-ended survey questions using the NVIVO qualitative analysis. To identify recurring themes, we used a bottom-up inductive analysis approach [37] and iterated on our coding scheme several times. The first author led the discussions and made revisions based on the research team's feedback. For example, to analyze our open-ended survey questions, we first inspected about 10% of the answers and tried to capture the emerging trends in general categories, and then refined the codes as new insights would emerge. Once the coding scheme was finalized, we applied it to the remaining answers. Since our surveys and interviews produced a large amount of data, we combined the key insights into major themes and are presenting them together in our results.

3 RESULTS

Our analysis revealed recurring themes related to students' preferences for external resources, use of trial-and-error strategies, and overall reluctance to seek help.

3.1 Students' reliance on external resources

Both of the survey results and interviews indicated that students were actively using the internal resources (Table 1) offered by the instructor. In fact, 82.4% of S1 respondents, 84.5% of S2 respondents, and 10/13 interviewees indicated using internal resources first. Many of the students even agreed with the sentiment that *"the [instructor]'s teaching and the [course] materials provided were pretty good"* (P13). However, we observed that students' learning was strongly intertwined with external web-based resources, consistent with other studies of university students [9, 43]. When we asked students about their top three preferred resources (from Table 1), 98.0% of S1 respondents and 70.6% of S2 respondents selected at least one external resource, with external forums being the most popular choice. Interestingly, 16.7% of S1 respondents and 15.5% of S2 respondents preferred to skip internal resources altogether and started searching for resources on their own first.

Our participants shared different reasons for consulting external resources even when the provided internal resources were perceived to be helpful. The students' primary desire was to save time and effort and be as efficient as possible: *"it's easier to just search (on Google)"* (P9). Students preferred to obtain code examples right away instead of looking for an explanation in the provided materials. For example, one of our participants admitted that *"I don't want to look through the textbook if I don't know that my answer is there, so I just Google the exact question, and then chances are it comes up"* (P10). Another participant further explained how he looked for code examples that could be repurposed: *"I find it easy to look at someone else's code and then take that method and use it for myself... I don't read the interactive textbook because it has too many words"* (P12). Our participants' preferences for external resources were grounded in their optimistic beliefs, such as *"the Internet has all the knowledge, it is hard to fail looking for resources" (P12).*

About half of the interviewees (6/13) admitted that they started by copying and pasting the exact question from an assignment into Google. A recurring theme that emerged in the responses was the desire to obtain *'exact matches'* in code examples over explanations to fully understand the underlying concepts. Sometimes students' expectations were somewhat unrealistic and they even realized that: *"...this (copying/pasting) obviously doesn't work because you can't find every assignment on Google"* (P11). In one of our open-ended questions in S2, 44.1% of participants indicated that the main reason to use external resources was *"when I want to get hints, I explore different methods or find ideas for inspiration"*. This was slightly more than participants who used external resources because they *"perceived a gap in their resources or knowledge"* (38.7%, S2). In terms of when they were the most likely to abandon or give up a particular external resource, the highest proportion of S2 respondents (31.8%) said that the most relevant reason was *"when I can't find the exact answer to my question"*. This was higher than those who said that they would give up on a particular resource *"when it fails to explain [the] provided code or terminology"* (26.1%, S2).

Overall, participants valued external resources for quickly locating examples or ideas to try, but a consistent problem for participants was locating the *'right'* answer, buried in a 'sea of resources': *"It may take more time sorting through the resources and finding which one I want to use...finding one that's easy to understand is probably what takes the bulk amount of time"*. (P5).

3.2 Trial-and-error strategies dominate the quest for finding resources

As discussed above, most of our participants were interested in exact matches when they consulted external resources. We learned that

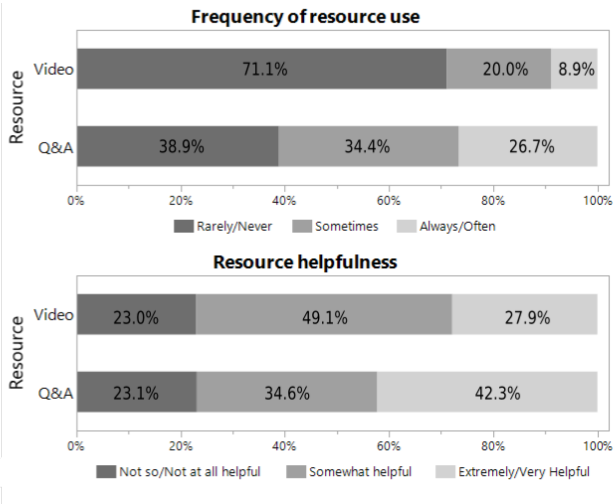

Figure 1: In S2, 26.7% of respondents said that they always/often used Q&A, compared to 8.9% for videos. Moreover, most respondents (42.3%) found Q&A to be extremely/very helpful, compared to videos (27.9%). Other resources are not reported due to lower usage and inconsistency.

they mostly followed a trial-and-error approach and sifted through as many resources as possible without a clear path. For example, the most popular query on Google (44.5%, S2) was a simple and generic *"how to do (something) in Python"*, but locating a relevant answer required multiple attempts. For example, one of our interviewees indicated: *"sometimes when you search some things, it's not relevant and you know it right away, so then you have to go and search for another thing to see if you can find something more relevant"* (P3). However, they lacked sufficient knowledge to assess the relevance of search results and resorted to *"just guessing and reading ahead"* (P2). This back-and-forth process was frustrating for participants: *"sometimes it works, sometimes it doesn't. A lot of trial and error and a lot of I think I know, let's do it, oh, it didn't work!"* (P9). Others believed that obtaining the right resource, *"would depend on whether or not I'm lucky, I guess"* (P1).

One of the reasons why our participants were stuck in the trial-and-error process was their lack of understanding of programming concepts and relevant terminology. Since they were first year programming students, we learned that the most frequent difficulty our respondents faced was not knowing *" how to interpret the given problem or what I am expected to do"* (34.5%, S1). As some of our interviewees admitted: *"the problem is I don't know where to start"* (P9) and *"don't know what I'm supposed to tell the computer to do"* (P3). As one of our interviewees explained, they believed that *"trial and error is a good thing"* (P12). By using trial-and-error, they tried to avoid reading *"a whole paragraph about [a topic] when there's only one thing to say"* (P6). Through trial-and-error, our study participants were looking for *"just quick, succinct answers"* (P8).

Another reason why students resorted to trial-and-error was to be efficient and spend the least possible time and effort in working on their programming assignments. For example, in S1, respondents indicated that *"solving the programming exercises in a timely manner"* was the most preferred way to measure their learning progress (41.7%, S1). From our interviews, we learned that students optimized their time by relying mostly on Q&A resources, such as *StackOverflow*, which contained code examples. These Q&A forums were the most preferred resource (9/13) and about half of the interviewees (6/13) used it as their first choice. In contrast, online videos that provided more novice-friendly explanations of programming concepts were the next preferred resource (7/13), but used only by a few interviewees (3/13). Similarity, only a handful of interviewees (3/13) mentioned using other web pages (such as Python documentation). None of the interviewees used web pages as a first resource as they were not as *'efficient'* as forum posts.

3.3 Incessant Use of Q&A forums

In S2 we asked specific questions about the frequency and usefulness of the top external resources mentioned by our interviewees, namely forums and videos (we excluded web pages from our analysis due to their lower usage, lack of internal consistency, and possible confusion with the use of the *Google* web page). As shown in Fig. 1, S2 respondents said they used Q&A sites always or often (26.7%) compared to online videos (8.9%). These respondents also found Q&A sites to be very helpful or extremely helpful (42.3%) compared to online videos (27.9%). Overall, participants considered videos to be more instructive and oriented towards beginners like them: *"[when] I need someone to explain the information to me so then I go watch videos"* (P1). Another interviewee explained that *"a video is helpful in making sure you understand the basics"* (P4). Most of the respondents agreed that videos *"provide clear explanations, they are very instructive"* (42.0%, S2).

Despite the utility of videos, more participants were still attracted to Q&A sites. A consistent feeling expressed by almost all of the interviewees was that: *"they [Q&A sites] include similar questions to the ones I have right now"* (37.5%, S2). This incessant preference for Q&A seems paradoxical because students also considered Q&A resources to be complex and hard to understand: *"Stack Overflow has answers that are, God knows how long, and then it has so much code and such a complex way that you can't apply it to this course"* (P12). Still, P12 explained how the code found on *StackOverflow* was used even when it was not fully understood: *"I generally look at the problem and then I'll look at many resources and now I'll just create a puzzle in my head of how each code works and for some reason it works."* (P12). P3 concurred: *"I'm pooling a lot of bits of code here and there together, to get to my goal of what I need"* (P3). Overall, participants exhibited an opportunistic behaviour in locating external resources and Q&A posts in particular.

3.4 Students' perceptions of wasted time and reluctance to seek help

As discussed above, our participants consulted external resources to try to get exact matches for their programming-related questions. In S1, we learned that most students (41.7%) preferred *"solving the programming exercises in a timely manner"*. In S2, we observed that another key desired goal was *"solving the exercises without asking anyone"* (28.9%). But, surprisingly, in hopes of being efficient, the participants admitted to wasting hours on Google and struggled to obtain relevant resources. Furthermore, what we observed was somewhat of a paradox: even after wasting time and struggling with external resources, participants were reluctant to change their strategy or ask for help.

In S2, we probed into students' perceptions of time and surprisingly found that 22.7% agreed or strongly agreed that they were actually wasting time with external resources, and a large number of them (28.4%) were neutral. Most interviewees (11/13) confirmed that looking for external resources was a time-consuming process with no guarantee for success. As one interviewee explained: *"I apply what I learned from the video or website to my work... it does sometimes take even a full day, so I do admit that I waste a lot of time"* (P11). In contrast, other students disagreed: *"It shouldn't matter if you spend two days or one minute looking for external resources, if it's towards answering a specific problem and you need to find the answer, it can never be a waste of time"* (P12).

We observed that participants held a strong conviction that external resources could be time-saving shortcuts and they just needed to keep looking: *"as a student, there's a battle against time, you know? There are deadlines to meet, and homework... it's due at a certain time so if I'm running out of time for the assignment it's best to just [try], Oh, this is how this person did it, that must be right. I'll do the same thing...it cuts down the steps."* (P8). Another participant explained: *"yes, it takes a lot of time, because a lot of the questions that are asked on Q&A websites are not the exact solution to what you are looking for"* (P9). For such students, finding the 'exact solution' was not enough: they also wanted the solution to be 'easy to understand'.

Although most of our participants felt that it was costly in terms of time and effort to keep looking for external resources, surprisingly, they did not want to stop and seek help. The pursuit of external resources was perceived as being more efficient as long as *"the right resource comes up"* during the search. In S1, not a single participant indicated that they would post questions in external forums, and only a few (1.2%) had ever posted in the internal forums for the course. In the interviews, none of the participants indicated that they would consider posting a new question to a forum such as *StackOverflow* and only 2/13 mentioned they would consider posting to the internal forum. Furthermore, only 4/13 indicated that they would consider consulting the TAs or the course instructor.

For some interviewees, asking for help involved a high social cost as they were not confident in their own terminologies for phrasing the appropriate question. Some students also perceived the instructor or TAs to be *less helpful* as they would normally offer conceptual explanations or mere hints rather than the exact answer. The response would also be delayed compared to the instant gratification offered by a Google search. Wherever possible, our participants preferred code examples and explanations that contained exact matches to their queries. However, asking for this level of guidance from the instructor or TAs was considered to be 'inappropriate': *"I do waste a lot of time looking for resources, and I think I justify that because I don't really want to go to the TA or the professor with every little problem I have. So I really like to save going to them for big problems that I absolutely cannot solve or get help at all"* (P11). Unfortunately, most students ended up in a never-ending cycle of going back-and-forth online with little success: *"the longer I take [to obtain the right resource], the more frustrated I get. So the more frustrated I am, the more I realize it is taking me too much time to look for resources"* (P8).

4 DISCUSSION

We presented a detailed case study of how students in a CS1 course perceive and use different learning resources offered by the course instructor vs. web-resources they locate on their own. Through two surveys and follow-up interviews, we observed that students in CS1 preferred quick and exact matches to their queries and mostly relied on Q&A resources. Our participants were less likely to use online videos, even though they found these videos to be more suitable for beginners like them. Since our participants were mostly new to programming, they had several problems in understanding programming terminologies and struggled to make sense of the retrieved code examples, ending up in a lengthy trial-and-error process. Although most students realized to some extent that they were wasting their time by relying on trial-and-error, ironically, they incessantly continued with this approach of searching the web and were reluctant to seek help from instructors or TAs.

We reflect on our findings and discuss implications for future research in the context of learning sciences and information sciences.

4.1 Production bias and opportunistic behaviours among students

Our participants believed that the approach of looking for quick and exact answers would be more optimal than understanding the concepts and foundations offered in the internal resources. The students' insistence on looking for answers on their own and not asking for help bears similarity to the concept of the *Active User Paradox* [5] or AUP which explains that users optimize their behaviour to complete the immediate task rather than investing time in learning the relevant conceptual details. This behaviour is also similar to the idea of *production bias* because users have a bias towards producing rather than learning the proper techniques for completing the tasks [6]. Studies related to the AUP show that users aim to achieve a stable sub-optimal performance using small, repetitive interactive tasks with fast and incremental feedback, even though more efficient procedures may exist [17]. We found that our participants had a similar motivation for using Q&A resources as they sought ideas they could quickly try.

Another way to understand our findings is through the lens of the *Information Foraging Theory* [33]. This theory explains how users forage for information opportunistically in the same way animals forage for food. With this lens, our participants can be seen as wandering from resource to resource [20], focusing only on what they need and ignoring other bits of information [2]. Similar to how animals try to find specific food while minimizing energy usage, our participants used shallow and quick trial-and-error strategies and made use of Q&A forums to minimize the time they needed to understand the more complex underlying concepts.

4.2 Relying on luck and gambling for answers

Our participants' overall attitude was that the answers are *"out there"* and it was just about *"getting lucky"*. In some ways, students could be seen as gambling with their chances. The presence of Google's famous button *I'm feeling lucky* suggests that there is an element of luck when looking for information [23]. Gambling is one of the most frequent endeavours across all cultures and ages [1] and some of our participants' behaviours resemble the characteristics of gambling [44]. For example, to achieve the desired prize (a relevant answer), students were willing to put something at stake: their time and trail of personal data online. Both of these aspects (time and data) [26, 46] have been shown to be easily exploited by internet advertisers [16, 36]. Furthermore, we found that similar to gambling where the outcome of the game is uncertain, our participants also expressed uncertainty in looking for exact answers online but were willing to take their chances. Most of them were relying on luck to hit the jackpot (a useful answer that they could actually understand and apply) and had heightened perceptions of personal luck near deadlines, a characteristic commonly observed with increasing wagers in gambling [45].

4.3 Behaviours of first-year students vs. professional programmers

Even though the majority of our participants had no prior experience with programming, it was interesting to see how similar their behaviour was to professional programmers. For example, professional programmers have also been shown to opportunistically forage for resources in Q&A forums when they are learning about new programming techniques or troubleshooting their code [2, 3]. Professional programmers, in particular, prefer to look Q&A for explanations with source code examples [30] and opportunistically reuse code because they prioritize speed and ease of development over code robustness [3].

Despite some of the similarities that we observed in the use of Q&A forums among the first-year students in our study and prior research on professional programmers, there were some clear contrasts. For example, since professional programmers have expertise and knowledge of various terminologies, their use of forums is more targeted [29] compared to our participants who were relying on exact matches because they did not grasp the basic concepts. Additionally, unlike professional programmers who are usually systematic in their quest for resources [2], students relied on trial-and-error and struggled in assessing the relevance of resources that they were retrieving. Even though some prior work has explored the use of *StackOverflow* in programming courses [12, 24, 34], more research is needed to tease apart the differences in approaches used by first-year students and how they could be better supported.

4.4 Implications for researchers and educators

The insights from our study about CS1 students' reliance on external resources have important implications for researchers and instructors. In many ways, the desire for exact matches and use of Q&A resources could be considered *cheating*. Prior work has identified similar issues and proposed ideas to minimize cheating in CS1 [14, 27] and in particular from *StackOverflow* [32]. However, our results suggest that many of our participants were not wanting to cheat: they were mainly using external resources to obtain ideas to get unstuck. Perhaps resources catered to provide suggestions about how to approach a programming problem such as *Idea Garden* [4] may help. To help learners when they are stuck in a loop, past works have also proposed methods to circumvent the AUP [5] by using approaches such as the *HotKeyCoach* [22].

Another avenue that is worth investigating is how to minimize students' perception of social costs of asking for help and guidance in a learning environment [42] and encourage them to seek hints. It has been found that question anonymity and routed-respondent inquiries can reduce the perceived social costs in a Q&A forum [25], but more strategies for in-person help-seeking are needed.

In addition, our results suggest that the incessant reliance on external resources could be a result of students in CS1 having varying needs and learning goals. For example, prior work has identified the existence of *conversational programmers* [7] who mainly want to learn programming to better communicate with technical co-workers, not to develop software [7, 8]. For these learners, learning resources for programming that focus too much on syntax and logic and less on how to apply code to solve problems [41] are less effective. It would be worth investigating in future work the extent to which Q&A resources can support learners who care more about what code can achieve than how a programming language works [10].

Finally, we note that at the time of this study, the CS1 course was delivered remotely due to COVID-19 and reliance on external resources may have been unusually high. It is likely that after experiencing remote instruction, the expectations of both students and instructors will evolve. Future work can investigate whether there are any differences in students' decision-making processes when looking for resources in remote vs. in-person courses.

4.5 Limitations

Although our data was collected in a CS1 course that is comparable to other large offerings in North America and we conducted the study over two different terms, some caution should be used before generalizing the results as the data was based on self-report. We also note that there was variation in the number of CS majors enrolled in CS1 course that we studied: summer terms were more heterogeneous than fall terms considering students' majors with a variation from 30% to 50% CS majors. Although we did not observe any differences in results from CS compared to non-CS students across both terms, future work can tease apart differences between CS and non-CS students and their information behaviours.

5 CONCLUSIONS

Our study provides insights into how students in an introductory programming course relied on external resources, such as Q&A forums, and how they focused on locating efficient exact matches. But, since these students were learning programming for the first time, they faced several challenges and struggled to perform proper queries and assess the relevance of the results. These students incessantly used trial-and-error strategies and wasted a large amount of time in hopes of getting lucky and spent little time on understanding the concepts. Finally, these students were reluctant to seek help and improve their learning strategies as they perceived high social costs with help-seeking. Our paper contextualizes these insights in light of existing theories and explanations and provides pointers to address this emerging issue in future work.

ACKNOWLEDGMENTS

We thank the Natural Sciences and Engineering Research Council of Canada (NSERC) for funding this research.

REFERENCES

[1] Darrell W Bolen and William H Boyd. 1968. Gambling and the gambler: A review and preliminary findings. *Archives of general psychiatry* 18, 5 (1968), 617–630.

[2] Joel Brandt, Philip J Guo, Joel Lewenstein, Mira Dontcheva, and Scott R Klemmer. 2009. Two studies of opportunistic programming: interleaving web foraging, learning, and writing code. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 1589–1598.

[3] Joel Brandt, Philip J Guo, Joel Lewenstein, and Scott R Klemmer. 2008. Opportunistic programming: How rapid ideation and prototyping occur in practice. In *Proceedings of the 4th international workshop on End-user software engineering*. 1–5.

[4] Jill Cao, Scott D Fleming, Margaret Burnett, and Christopher Scaffidi. 2015. Idea Garden: Situated support for problem solving by end-user programmers. *Interacting with Computers* 27, 6 (2015), 640–660.

[5] John M Carroll and Mary Beth Rosson. 1987. Paradox of the active user. In *Interfacing thought: Cognitive aspects of human-computer interaction*. 80–111.

[6] Michelle Carter, Jeffrey A Clements, Jason Bennett Thatcher, and Joey F George. 2011. Unraveling the" paradox of the active user": Determinants of individuals' innovation with it-based work routines.. In *AMCIS*.

[7] Parmit K Chilana, Celena Alcock, Shruti Dembla, Anson Ho, Ada Hurst, Brett Armstrong, and Philip J Guo. 2015. Perceptions of non-CS majors in intro programming: The rise of the conversational programmer. In *2015 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC)*. IEEE, 251–259.

[8] Parmit K Chilana, Rishabh Singh, and Philip J Guo. 2016. Understanding conversational programmers: A perspective from the software industry. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. 1462–1472.

[9] Donald Chinn, Judy Sheard, Angela Carbone, and Mikko-Jussi Laakso. 2010. Study habits of CS1 students: what do they do outside the classroom?. In *Proceedings of the Twelfth Australasian Conference on Computing Education-Volume 103*. 53–62.

[10] Kathryn Cunningham, Barbara J Ericson, Rahul Agrawal Bejarano, and Mark Guzdial. 2021. Avoiding the Turing Tarpit: Learning Conversational Programming by Starting from Code's Purpose. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. 1–15.

[11] Pierpaolo Dondio and Suha Shaheen. 2019. Is StackOverflow an Effective Complement to Gaining Practical Knowledge Compared to Traditional Computer Science Learning?. In *Proceedings of the 2019 11th International Conference on Education Technology and Computers*. 132–138.

[12] Pierpaolo Dondio and Suha Shaheen. 2019. Is StackOverflow an Effective Complement to Gaining Practical Knowledge Compared to Traditional Computer Science Learning?. In *Proceedings of the 2019 11th International Conference on Education Technology and Computers* (Amsterdam, Netherlands) *(ICETC 2019)*. Association for Computing Machinery, New York, NY, USA, 132–138. https://doi.org/10.1145/3369255.3369258

[13] Peter Draus. 2020. Impact of student engagement strategies on video content in learning computer programming and attitudes towards video instruction that was developed based on the cognitive theory of multimedia learning. *Issues in Information Systems* 21, 3 (2020).

[14] Alex Edgcomb, Frank Vahid, Roman Lysecky, and Susan Lysecky. 2017. Getting students to earnestly do reading, studying, and homework in an introductory programming class. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*. 171–176.

[15] Barbara J Ericson and Bradley N Miller. 2020. Runestone: A Platform for Free, Online, and Interactive Ebooks. In *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*. 1012–1018.

[16] Asunción Esteve. 2017. The business of personal data: Google, Facebook, and privacy issues in the EU and the USA. *International Data Privacy Law* 7, 1 (2017), 36–47.

[17] Wai-Tat Fu and Wayne D Gray. 2004. Resolving the paradox of the active user: Stable suboptimal performance in interactive tasks. *Cognitive science* 28, 6 (2004), 901–935.

[18] Philip J Guo, Julia M Markel, and Xiong Zhang. 2020. Learnersourcing at scale to overcome expert blind spots for introductory programming: a three-year deployment study on the python tutor website. In *Proceedings of the Seventh ACM Conference on Learning@ Scale*. 301–304.

[19] Qiang Hao, Brad Barnes, Ewan Wright, and Robert Maribe Branch. 2017. The influence of achievement goals on online help seeking of computer science students. *British Journal of Educational Technology* 48, 6 (2017), 1273–1283.

[20] Jane Hsieh, Michael Xieyang Liu, Brad A Myers, and Aniket Kittur. 2018. An exploratory study of web foraging to understand and support programming decisions. In *2018 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC)*. IEEE, 305–306.

[21] Adrian Kirkwood. 2008. Getting it from the Web: why and how online resources are used by independent undergraduate learners. *Journal of Computer Assisted Learning* 24, 5 (2008), 372–382.

[22] Brian Krisler and Richard Alterman. 2008. Training towards Mastery: Overcoming the Active User Paradox. In *Proceedings of the 5th Nordic Conference on Human-Computer Interaction: Building Bridges* (Lund, Sweden) *(NordiCHI '08)*. Association for Computing Machinery, New York, NY, USA, 239–248.

[23] Corinne Laverty, Brenda Reed, and Elizabeth Lee. 2008. The "I'm feeling lucky syndrome": Teacher-candidates' knowledge of web searching strategies. *Partnership: the Canadian Journal of Library and information practice and research* 3, 1 (2008).

[24] Martín López-Nores, Yolanda Blanco-Fernández, Jack F Bravo-Torres, José J Pazos-Arias, Alberto Gil-Solla, and Manuel Ramos-Cabrer. 2019. Experiences from placing Stack Overflow at the core of an intermediate programming course. *Computer Applications in Engineering Education* 27, 3 (2019), 698–707.

[25] Haiwei Ma, Bowen Yu, Hao Fei Cheng, and Haiyi Zhu. 2019. Understanding Social Costs in Online Question Asking. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI EA '19)*. Association for Computing Machinery, New York, NY, USA, 1–6.

[26] Gianclaudio Malgieri and Bart Custers. 2018. Pricing privacy–the right to know the value of your personal data. *Computer Law & Security Review* 34, 2 (2018), 289–303.

[27] Tony Mason, Ada Gavrilovska, and David A Joyner. 2019. Collaboration versus cheating: Reducing code plagiarism in an online MS computer science program. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*. 1004–1010.

[28] Bradley N. Miller and David L. Ranum. 2012. Beyond PDF and EPub: Toward an Interactive Textbook. In *Proceedings of the 17th ACM Annual Conference on Innovation and Technology in Computer Science Education* (Haifa, Israel) *(ITiCSE '12)*. ACM, New York, NY, USA, 150–155.

[29] Patrick Morrison and Emerson Murphy-Hill. 2013. Is programming knowledge related to age? an exploration of stack overflow. In *2013 10th Working Conference on Mining Software Repositories (MSR)*. IEEE, 69–72.

[30] Seyed Mehdi Nasehi, Jonathan Sillito, Frank Maurer, and Chris Burns. 2012. What makes a good code example?: A study of programming Q&A in StackOverflow. In *2012 28th IEEE International Conference on Software Maintenance (ICSM)*. IEEE, 25–34.

[31] Engineering National Academies of Sciences, Medicine, et al. 2018. *Assessing and responding to the growth of computer science undergraduate enrollments*. National Academies Press.

[32] Gabriel Orlanski and Alex Gittens. 2021. Reading StackOverflow Encourages Cheating: Adding Question Text Improves Extractive Code Generation. arXiv:2106.04447 [cs.CL]

[33] Peter Pirolli and Stuart Card. 1999. Information foraging. *Psychological review* 106, 4 (1999), 643.

[34] Jaanus Pöial. 2020. Challenges of Teaching Programming in StackOverflow Era. In *International Conference on Interactive Collaborative Learning*. Springer, 703–710.

[35] Lori Postner and Reed Stevens. 2005. What resources do CS1 students use and how do they use them? *Computer Science Education* 15, 3 (2005), 165–182.

[36] Bruce Schneier. 2015. *Data and Goliath: The hidden battles to collect your data and control your world*. WW Norton & Company.

[37] Anselm Strauss and Juliet Corbin. 1990. *Basics of qualitative research*. Sage publications.

[38] Don R Swanson. 1977. Information retrieval as a trial-and-error process. *The Library Quarterly* 47, 2 (1977), 128–148.

[39] Roberto Truzoli, Caterina Viganò, Paolo Gabriele Galmozzi, and Phil Reed. 2020. Problematic internet use and study motivation in higher education. *Journal of Computer Assisted Learning* 36, 4 (2020), 480–486.

[40] Giovanni Vincenti, J Scott Hilberg, and James Braman. 2017. Student preferences and concerns about supplemental instructional material in CS0/CS1/CS2 courses. *International Journal on E-Learning* 16, 4 (2017), 417–441.

[41] April Y Wang, Ryan Mitts, Philip J Guo, and Parmit K Chilana. 2018. Mismatch of expectations: How modern learning resources fail conversational programmers. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–13.

[42] Joe Warren, Scott Rixner, John Greiner, and Stephen Wong. 2014. Facilitating Human Interaction in an Online Programming Course. In *Proceedings of the 45th ACM Technical Symposium on Computer Science Education* (Atlanta, Georgia, USA) *(SIGCSE '14)*. Association for Computing Machinery, New York, NY, USA, 665–670. https://doi.org/10.1145/2538862.2538893

[43] David Weintrop, David Bau, and Uri Wilensky. 2019. The cloud is the limit: A case study of programming on the web, with the web. *International Journal of Child-Computer Interaction* 20 (2019), 1–8.

[44] Robert J Williams, Rachel A Volberg, Rhys MG Stevens, Lauren A Williams, and Jennifer N Arthur. 2017. *The definition, dimensionalization, and assessment of gambling participation*. Technical Report. Canadian Consortium for Gambling Research.

[45] Michael JA Wohl and Michael E Enzle. 2003. The effects of near wins and near losses on self-perceived personal luck and subsequent gambling behavior. *Journal of experimental social psychology* 39, 2 (2003), 184–191.

[46] Shuai Yuan, Jun Wang, and Xiaoxue Zhao. 2013. Real-time bidding for online advertising: measurement and analysis. In *Proceedings of the Seventh International Workshop on Data Mining for Online Advertising*. 1–8.