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The Undervalued Disciplinary and Emotional Support Provided By Teaching Assistants in Introductory Computer Science Courses

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Abstract: In computer science (CS) higher education, many students in introductory courses (CS1) struggle to learn programming due to both the complexity of the discipline and negative affective experiences while learning. Large class sizes hinder the opportunity to receive support that addresses both disciplinary knowledge and affective experiences, both of which have been shown to influence self-efficacy. Our work utilized a combination of structured daily diaries and retrospective interviews to surface participants' programming experiences, affective responses, and self-perceptions. Through two case studies, we highlight the intertwined nature of disciplinary knowledge and affective experiences in the learning process of students in CS1, and advocate for increased attention to student interactions with TAs as an opportunity to provide affective support along with disciplinary learning.

Introduction and Background

Many students in introductory CS courses (CS1) struggle to learn programming, contributing to low levels of persistence and sustained interest among students (Porter & Simon, 2013). Students struggle to learn disciplinary skills such as systematic debugging, adaptive planning, and problem-solving (Li et al., 2019). Concurrently, negative affective experiences while programming, like frustration and confusion, further compound these struggles. These intertwined challenges of disciplinary knowledge and affective experiences significantly shape students' assessments of their self-efficacy (Kinnunen & Simon, 2012). Consequently, students need support in both developing disciplinary skills and navigating the affective dimensions of their learning experiences.

In CS1 courses, with enrollments often exceeding 200 students, limited social interactions pose a challenge. Researchers have shown that social interactions with instructors can both demonstrate disciplinary thinking processes and learning strategies (Margulieux, 2019) and shape students' perceptions of themselves and their interests and motivations in pursuing CS (Säde et al., 2019). However, most CS1 courses are too large to support this approach. As a result, these courses rely on teaching assistants (TAs) to offer the necessary mentorship and social interactions for students (Mirza et al., 2019). We suggest this context of student-TA interactions could serve as an opportunity for students to receive support that covers both disciplinary knowledge and affective dimensions.

In both research and practice, however, the role of the TA in CS1 is conceptualized around providing disciplinary help (Estrada & Tafliovich, 2017) rather than supporting student emotions and developing self-efficacy. Given the discussions in other fields about the impact of social interactions that provide affirmation, express compassion, and provide constructive feedback on students' self-efficacy (Harburg et al., 2018), there is a noticeable gap in the literature regarding how social interactions within the CS1 classroom context can provide support for the intricately interwoven disciplinary and affective dimensions of student learning.

Our study aims to better understand student experiences in their CS1 courses within the context of their interactions with TAs. Research on office hours discusses the help-seeking process from both students' and TAs' perspectives (Markel and Guo 2021; Ko & Stephens-Martinez, 2023). Few researchers have discussed how interactions with TAs impact student experiences. Perlmutter et al. (2023) conducted interviews with seven pairs of students and TAs who interacted during office hours and found that TA actions potentially influence students' sense of belonging. Our study expands this area by investigating the support students receive from TAs and its impact on students' disciplinary learning, affective dimensions, and self-efficacy.

We present two detailed cases of students enrolled in a CS1 course aimed at non-majors. To capture student reflections on their experiences, participants completed daily diaries throughout a homework cycle, in which they responded to prompts about their learning activities and emotions each day. At the end of the week, they completed a retrospective interview with the first author to elaborate on the content reported in their diary. The two cases show a blurred boundary between affective validation and disciplinary feedback when students seek help from TAs. We characterize two different approaches employed by TAs for providing support from the experiences students shared. We argue for increased attention to student interactions with TAs in course design, and advocate for leveraging these interactions to provide affective support along with disciplinary learning, which has the potential to improve student self-efficacy.

Methodology

The research was conducted within a CS1 course for non-majors. Prior programming experience is not required for this course. During Spring 2023, we recruited eight students from CS1 for the study. All participants who completed the study were monetarily compensated for their time. The research utilized a combination of structured daily diaries and retrospective interviews, each offering unique insights into the participants' behaviors and affective experiences. Data collection took place over one week. Students completed diaries each day and then completed a retrospective interview with a researcher after they completed the diary.

We inductively code participants' daily diary responses and retrospective interview transcripts. The initial open coding identified participants' diverse motivations in help-seeking, types of support TA provided; affective responses; and judgments about themselves and CS as a subject area. Then, we clustered initial codes into disciplinary knowledge, affective experiences, and self-efficacy. The two cases illustrate learners' help-seeking experiences with TA and the momentary outcomes from the experiences.

Findings

We present two representative cases, using pseudonyms Sylvia and Anne, to illustrate TA-student interactions supporting CS learning. Slyvia is a sophomore majoring in social policy who has no prior experiences in CS. Anne is a junior majoring in theater, also with no previous experiences in CS. In their diaries, they both exhibited negative emotions and low self-efficacy while learning CS. Sylvia expressed a preference for learning through social interactions with TAs and their friends. Positive affirmation and constructive feedback from TAs played a pivotal role in building Sylvia's confidence and learning programming. In contrast, Anne tended to avoid interacting with TAs due to the fear of exposing her lack of understanding. However, her first interaction with TAs, prompted by the approaching deadline, proved to be encouraging, making her feel "not stupid". Although the two participants held different initial attitudes toward interacting with TAs, both received valuable support from TAs covering both disciplinary and affective dimensions.

"I hate you sincerely, Python": seeking "positive reinforcement" from TAs

Sylvia is very unconfident and exhibits low self-efficacy in computing. Sylvia acknowledged the importance of learning CS in a social setting so that they could receive support. Sylvia highly valued the effectiveness of the weekly tutorial sessions, a small group session with 10 people or so led by a TA, where she received immediate feedback and guidance to remove the mental block during their work, and at the same time, felt supported and comfortable. Beyond receiving help with content knowledge, Sylvia also benefited from "the reassurance of a TA," offering emotional support as Sylvia expressed the feeling of "not slowing anybody down." The social interaction with TAs in a smaller environment provided a safer, supportive space that eased Sylvia's anxiety.

The interviewer encouraged Sylvia to pretend the interviewer was the TA in an office hours scenario and she was there to ask about her homework. Sylvia initially asked vague questions, expressing uncertainty and a general sense that there should be a proper way to complete this homework. The interviewer followed up by asking "why do you think what you did is not proper", guiding her to describe her problems in detail and identify the problems by herself. After the interviewer prompted Sylvia to elaborate on their questions, she started reflecting on what she was trying to achieve and failed to achieve, showcasing a growing awareness of her problem. Sylvia aimed to seek validation from TAs regarding the correctness of their previous approach. Additionally, Sylvia also sought validation for her proposed alternative solutions to their questions. She highlighted that the step-by-step confirmation and guidance from the TA made them more confident in her programming practices.

The interviewer further affirmed Sylvia's ability to problem solve and pointed out Sylvia's lack of confidence. Sylvia strongly agreed and expressed frustration from working individually and receiving only negative feedback in the form of error messages from the programming environment.

> Sylvia: Yeah! Especially walking myself through it alone, and it's like me in bed, hunching over my screen, eyes are either dry or like tears are coming out of them. It is not working out. I think, just again, the positive reinforcement of, 'you're doing this right', or 'this is a good idea', or 'why don't you try that', or 'here's what you could do', like those constructive things, as opposed to like 'error', 'you're wrong', 'I hate you sincerely, Python'. The constructive feedback and the positive reinforcement, especially from a person, are really helpful.

The above segment highlights a significant difference between feedback from a human and feedback from the programming environment. The error messages failed to provide any encouragement that would motivate Sylvia

to keep trying, and might even be the source of Sylvia's binary perception of their code as either right or wrong. In contrast, the interaction with TA provided Sylvia both constructive feedback on how to solve their problems and positive reinforcement so that they feel encouraged. For a student with low self-efficacy in the class, social interactions appear to be the most effective approach for facilitating learning.

Sylvia's case demonstrates the potential of TA-student interactions in providing emotional support to students. Through providing positive affirmation of their problem-solving approach and constructive feedback, these interactions effectively addressed their negative affective experiences.

"I'm not stupid": receiving encouragement despite TAs failing in problem-solving

In Anne's daily diaries, she consistently documented negative emotions following her CS learning experiences. Based on these negative emotions reported in her diaries, we started the interview by asking how these emotions influenced her. Anne answered that although frustration motivated trying, prolonged frustration led to diminished motivation and emotional fatigue.

Anne's persistence during moments of frustration is her wish to avoid demonstrating failure to others. Anne perceives being unable to solve problems or comprehend concepts as a form of failure. Consequently, Anne said that the avoidance of others seeing her struggles impacts her seeking help from TAs. The reluctance to seek help stemmed from feelings of shame, the comparisons with other students who appeared to understand faster, and the fear of falling behind. At the same time, she drew a connection between understanding slowly or struggling with the content and the feeling of failure and lack of intelligence.

During that week, the deadline was approaching but she was still unable to troubleshoot the errors. Anne decided to attend office hours and seek help from a TA.

> Anne: Yesterday I didn't have class, so I couldn't ask a classmate in class, and a TA had office hours. So I went to their office hours, and I showed them my code. And I was like, 'I don't understand why this isn't working.' And the TA went 'me neither, and let's try this.' And the thing didn't work. And so they're like, 'let's try this' and that thing didn't work either. So finally, they're like, 'I think you should just post something on the anonymous online discussion platform and ask our Professor privately'. So I did, and it worked then. And that's the first time I've posted here to ask for help with my code yesterday.

Anne described how the TA worked with her on troubleshooting and demonstrated the trial-and-error process. Although they didn't solve Anne's problem during office hours, the TA offered suggestions that directed Anne to consult with the professor. For Anne, who is afraid of exposing her lack of understanding, the TA's suggestion to post the questions to professors served as reassurance that her asking questions doesn't make her appear stupid.

We were curious about how Anne perceived this experience, as she didn't resolve her problem in office hours with the TA. Anne perceived the experience positively. She said: "(I was) encouraged by the fact that they didn't know it either. I was like, oh, I'm not stupid, this person doesn't get it either. I felt better about myself." Despite being an authoritative figure in the student's eyes, the TA faced similar challenges as she did in the field of CS. The TA also conveyed that the debugging process for experienced programmers also takes time and effort. This experience showed Anne the way that CS professionals approach their work, which further reassured Anne that their struggles were not indicative of their intelligence. This alleviated Anne's feeling of shame.

Anne's case underscored that office hours with TAs served a broader purpose beyond addressing disciplinary knowledge help, specifically providing comprehensive social support. The TA's recognition of their shared struggles, and the collaborative troubleshooting process is as significant as resolving the questions the student raised. Such interactions not only improved students' understanding of the content knowledge, but also their negative emotions and self-assessments in CS learning.

Discussion and conclusion

In CS education, researchers have traditionally emphasized CS disciplinary knowledge. Our study highlights the intertwined nature of disciplinary knowledge and affective dimensions in students' learning process, and the potential in influencing students' self-perception in CS by addressing these together through social interactions.

We advocate for increasing the attention given to the social interaction between students and TAs during office hours or the small tutorial groups in course design. This approach can offer emotional support along with showcasing professional disciplinary skills, and has the potential to contribute to improved student self-efficacy. In Sylvia's case, the TA helped with the student's emotional regulation process. We observed that with the appraisal from TAs, Sylvia was able to move beyond the frustration and apprehension and re-engage in working back on the assignments.

In Anne's case, we observed a different way TAs provide social support, which is through demonstrating professional programming practices to students. In CS education literature, one factor for students from CS1 commonly experiencing negative self-efficacy is because of their inaccurate perceptions of professional programming practices (Gorson & O'Rourke, 2020). The TA-student interaction presented an opportunity to showcase professional practice, thereby correcting students' misperceptions and enhancing their self-efficacy. This case also illustrates implications for TA training programs. TAs often feel pressured by students' questions to provide solutions to programming problems in office hours. But as seen in our cases, TAs ought to acknowledge their uncertainty and model their debugging practices and usage of resources. This will better support students' CS learning.

We acknowledge our limited sample size and that there could be more diverse responses because of individual differences when working with a larger number of students. Future work could also benefit from direct observation of TA-student interactions and interviews with both students and TAs. Our findings suggest a broader space worth exploring—the potential of social interactions, encompassing the intertwined visible and invisible support provided by TAs in large courses for students.

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