Metacognition in Computer Science Learning: Perception vs. Reality

Mark S. Kim[1]
Hannah Simon[2]
Shasta Ihorn[3]
Anagha Kulkarni[4]

Introduction

Many computer science students enter college with ***little to no prior experience*** in the field, which can negatively impact their confidence and academic performance (Alvarado et al., 2018). To address this challenge, we introduced a four-day online winter bootcamp designed to bridge the gap between introductory and intermediate computer science courses. This bootcamp aims to boost students' confidence, minimize learning loss, and provide foundational support. In this qualitative study, we explore students' experiences and perceptions of learning computer science, focusing on how they navigate the learning process, the challenges they encounter, and their perceived proficiency. Ultimately, this research aims to provide insights that can help instructors support students' metacognitive development and offer effective scaffolding for learning at various levels.

Methods

- Participants: P = 21 first-year Computer Science students at SFSU, entering their second semester.
- Program Duration: T = 20 hours of a combination of lecture, group exercises, and exercise review.
- Surveys: Students completed a daily open-ended survey via Google Forms, reflecting on the effectiveness, enjoyment, learning outcomes, and self-assessed proficiency of each day's activities.
- Analysis:
  - **Thematic analysis** was performed on the survey responses following Braun and Clarke's (2006) guidelines.
  - Instructor notes and observations were integrated with the thematic analysis to examine any discrepancies between students' self-reported enjoyment/benefits and their observed engagement, as well as differences between self-assessed proficiency and actual performance.

Limitations

- Anonymous survey does not allow for an analysis of individual self-efficacy versus same-individual instructor-observed performance.
- In-class performance analysis and observations are biased towards the students with the highest participation.
- The length of each session may be a confounding factor with reporting the benefit and enjoyability of the sessions.
- Program participation is voluntary, so all exercises need to be attempted in-class; otherwise, exercises would never be completed before the next session.

SAN FRANCISCO STATE UNIVERSITY

First-year Computer Science students' self-reports on learning satisfaction clash with instructor observations. Their developing understanding may skew what they perceive as beneficial. To maximize both engagement and outcomes, it's essential to blend student feedback with instructor insight for the best of both worlds.

Please direct any questions or suggestions to: mkim22@mail.sfsu.edu

Results

Student self-reporting:

- Lectures and review of previous semester material were both **helpful** and **enjoyable** except for subjects that they were confident in (which varied significantly between students).
- Lab-like in-class exercises were both helpful and enjoyable, but **more enjoyable than helpful**.
- Explaining and examining exercise solutions was found to be the **most beneficial activity**.
- Opinions on group work was largely split, with some enjoying it and others finding it as the least helpful part of each session.
- Review of old concepts were generally seen as unbeneficial and unenjoyable.
- Overall enjoyment of each session was rated highly.
- The length of the sessions was **unanimously** considered the least enjoyable part of the program.

Instructor's Observations:

- Most students did not interact within the group breakout rooms.
- There was a wide range of expertise within the cohort.
- Students' understanding of many foundational concepts covered in the previous semester's Introduction to Programming course were underdeveloped.
- Lack of student engagement in all activities suggests that each session is not enjoyable.
- Exercises that repeatedly expose students to a particular concept produces the best results for knowledge retention and concept understanding

Discussion

There was a large disparity between the instructor's observations and students' self-reported experiences. Despite a universal and consistent lack of engagement, students reported high enjoyment and percieved benefit from various activities. This suggests that relying on instructor observations may not be effective for designing enjoyable learning experiences. Direct student feedback is likely be more valuable for informed lesson planning.

Students reported that in-class exercises were more enjoyable than helpful, but repeated exposure to specific skills resulted in increased engagement, retention, and understanding. This, coupled with their overconfidence in their knowledge, suggests that their ability to self-assess learning needs is still underdeveloped at this stage of their Computer Science education.

To optimize both enjoyment and effectiveness, combining direct feedback with scaffolded learning that aligns with students' developmental stage—ensuring they remain within their zone of proximal development (Vygotsky, 1975; Wood et al., 1976)—is key to creating a successful learning experience.

References

Alvarado, C., Umbelino, G., & Minnes, M. (2018). The persistent effect of pre-college computing experience on college CS course grades. *ACM Inroads 9(2)*, 58–64. https://doi.org/10.1145/3210551

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3(2)*, 77–101. https://doi.org/10.1191/1478088706qp063oa

Vygotsky, L. S. (1978). *Mind in Society: Development of Higher Psychological Processes* (M. Cole, V. Jolm-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press. https://doi.org/10.2307/j.ctvjf9vz4

Wood, D., Bruner, J. S., Ross, G., 1976. The Role of Tutoring in Problem Solving. *Journal of Child Psychology and Psychiatry, 17(2)*, 89-100. https://doi.org/10.1111/j.1469-7610.1976.tb00381.x

[1] Graduate Student, Data Science and Artificial Intelligence M.S. Program, Department of Computer Science, SFSU
[2] Undergraduate Student, Psychology B.S. Program, Department of Psychology, SFSU
[3] Associate Professor, Department of Psychology, SFSU
[4] Professor, Department of Computer Science, SFSU

NSF