Belonging and Successful Student Study Habits:

A Thematic Analysis of Student Study Patterns in Discrete Structures Course

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Introduction

At the University of Illinois at Urbana-Champaign, CS 173 is a discrete structures class that many computer science majors, computer science minors, and students in the interdisciplinary CS + X program may take towards the beginning of their undergraduate career. The course description yields insight into the theoretical nature of the course: “Discrete mathematical structures frequently encountered in the study of Computer Science. Sets, propositions, Boolean algebra, induction, recursion, relations, functions, and graphs” (Grainger Engineering Office of Marketing and Communications). Graduates who have studied computer science may understand that while these are fundamental concepts to the field, they require careful study in order to understand their structures and patterns, but also how to apply them to novel situations through academic applications and programming and demand a thorough understanding in mathematics before embarking.

This course expects that students have satisfied prerequisites in the following areas: CS 124 (Introduction to Computer Science I); and one of MATH 220 (Calculus) or MATH 221 (Calculus I) (Grainger Engineering Office of Marketing and Communications). For some computer science students, these prerequisites may have been satisfied during their high school career had they hailed from a community with the resources to support advanced placement mathematics and computer science courses; however, for others, this course is taken in the second semester or beyond, after satisfying the requirements. Even still, for many

students, this is their first discrete mathematics course and may require a new perspective for considering problems and new schema to develop.

Since CS 173 is a required course in the Bachelor's of Computer Science (University of Illinois at Urbana-Champaign); said another way, it cannot be substituted or skipped, so it is imperative for students to pass this course in order to continue with their computer science coursework. This course has garnered a reputation for being challenging and there are populations of students who reference the difficulty of this course due to the theoretical nature of the class; such as, the study of induction and proofs. In conjunction with this sentiment, upon completion, many students feel a sense of accomplishment in passing this course and recognize the relevance that these topics have in their other courses, computer science, and their future careers.

The course utilizes a “flipped classroom” technique where students are expected to prepare for class on their own time (e.g. read the textbook and watch the lecture videos) and then attend in-person weekly discussion sessions. These weekly discussion sections are held in two ways: as question-and-answer sessions with the teaching assistants traveling from student pod to student pod or a “town hall” style where students raise hands and pose questions to the TAs at the front of the lecture hall. In-person office hours are available from the professor and the TAs in addition to the weekly discussion sections as a resource for students to use.

With the blended learning environment, more resources have been created and consolidated for students to use as they deem fit for their studies. Most students will take ownership of their learning and discover the workflows that best fit their learning styles and needs, and this requires careful time management and insight into their preferred learning style. Understanding the variance in study habits and its impact on final grades, we sought to extend previous literature on analyzing time management, resources utilized, and sense of belonging to discover patterns of successful behavior in the CS 173 spring cohort.

Literature Review

Belonging can be defined as feeling affirmed and safe in a group, context, or environment. Research in computer science and belonging has shown that belonging may affect different facets of experiences in computer science; such as, earned grades (Goodenow 1993), their self image (Veilleux et al 2013), and a students decision to major in computer science (Lewis et al 2011).

Veilleux et al (2013) concluded that students' perception of their own abilities may be more influential to their feelings of belonging than their measurable skill set; said in another way, how a student feels about their ability to learn and demonstrate their skills may be more critical to their feelings of belonging. In a study of freshmen African American and white students, Hausmann, Schofield, and Woods (2007) found that students who had more peer-to-peer and professor interactions were more likely to have a higher sense of belonging than those who did not. It is possible that certain communities within the computer science field may feel different levels of belonging depending on their status in the majority or minority with regards to gender, race, religion, and other factors. It has been noted that women and people of color may exhibit a lower sense of belonging than their white male colleagues (Mooney et al 2020).

Other studies have explored learners' belonging in the context of motivation in fields outside of computer science. In a study outside of computer science while working under expectancy-value theory, Goodenow (1993) found that among adolescents in middle school, expectancy was the lead predictor of earned grades followed by belonging and value.

In computer science education research literature, there have been studies to pinpoint successful study skills and time management of computer scientist students (Willman et al, 2015; Beaubouef & Mason, 2005; Macan, Shahani, Dipboye, & Phillips, Citation 1990). As Willman et al (2015) summarize Macan et al (1990) study that found that students' time

management had a considerable impact on the students' "grades and stress levels". Specifically this study found that students who made a habit of studying and starting assignments in advance were more likely to earn high grades than students who did not start early (Willman et al 2015).

This appears to strengthen previous work from Edwards (2009) that found when partitioning students by grades into A/B and C/D/F that those with higher grades on average started a day earlier than lower grade earners. Longitudinal studies on time management and grade point averages were conducted by Britton and Tesser (1990) and found that time management was a more powerful predictor of GPA than earned SAT score.The central course of the study also had "mandatory tutorial sessions" that marked the first opening of an assignment and provided help to students generally was found to be impactful in students' final grades (Willman et al 2015).

Other studies looking to answer questions about student attrition in computer science university programs have cited time management as a hindrance for students. Beaubouef and Mason (2005) conclude that students struggle because of time management, especially when judging how long it will take to complete a programming assignment. They found evidence to support that students who start their programming assignments earlier were generally more successful with completion and with earned grades (Beaubouef & Mason 2005). Another impact on attrition was students' organization of resources and resource selection to complete tasks; students needed to balance computer lab time and save their progress on CDs, and the flexibility and adaptability required for time management was noted to take a few semesters of practice (Beaubouef & Mason 2005).

Other studies have honed in on specific categories of resources and how students perceive their usefulness. These studies hope to lend insight on how students select their study and assignment completing materials. Chinn et al (2010) observed and surveyed a CS1 course to measure students' perceptions on the usefulness of the resources provided. The results

showed that out of 94 students surveyed 67 rated “Lab and lab solutions” being most useful, with the textbook only having 34 as most useful. Other resources measured were previous programming experience, lecture attendance, tendency to work with others, and tutorials/tutorial solutions (Chinn et al 2010).

With many university courses and programs moving online or to a blended format, more research has arisen to measure students' study habits and performance. Sheshadri (2018) analyzed MOOCs to see if students’ online study habits could predict their performance. Their findings showed that “students’ study habits did differ based upon their level of performance and that key features of the study habits were significantly correlated with the students’ performance and final grades” (Sheshadri 2018). In addition, course participation and resource seeking peaked in the time periods before exams, which could show that students are revisiting resources to study for exams (Sheshadri 2018).

Methods

Data

During April and May of 2022, Professor Gertner conducted and recorded one-on-one virtual interviews over Zoom with students taking CS 173 (n = 17). These students identified themselves as freshmen or sophomores and were a combination of computer science, CS + X, and other majors who opted to take the course either out of curiosity for the content, part of a computer science minor, or as an elective. Students consented to have their interviews recorded and using an artificial intelligence speech-to-text transcriber, transcriptions were created. From there, the transcriptions were hand-corrected by playing back the recordings and fixing errors.

Interviews were generally between 17 and 26 minutes, and questions in the interview revolved around the following topics:

- Resources selected and regularly used for studying
- Studying routine with general time allotted to each resource
- Compare and contrast studying for this class with regards to their other classes
- Interest level and opinions of the CS 173 content.
- Expected course outcomes (e.g. if they would be successful, could do well in)
- Expected course effort and time management
- Emotional state during CS 173
- Procedures when solving problems (e.g. stepwise, trying it out)
- Advice to future students of CS 173

Metrics

To prepare for qualitative analysis of the themes in the interview data, codes or "noteworthy keywords" were discussed and selected. The main themes were Resources, Strategy, and Self with the addition of Exam and Course to account for additional insights.

- The "Resource" tag was used when a student mentions an item they used to study or that was present in their homework completion routines
- The "Strategy" tag was used when a student mentions a proposed action or plan as well as the context when said action or plan was performed.
- The "Self" tag was used when a student is reflecting on their own experiences, perceptions, or sense of belonging.
- The "Exam" tag was used rarely to capture any information about the structure or frequency of exams, also called "examlets".
- The "Course" tag was used rarely to note when an interviewee discussed the structure or perception of the course.
- The "Peers" tag was phased out and not counted in the formal analysis.

Within these three main large themes (Resource, Strategy, and Self), smaller sub themes emerged to provide the foundation for a more granular analysis:

- Resource
    - Discussion Sections: When used as a resource implies that the student attended the once-a-week, in person discussion section.
    - External: When a student mentions seeking out an outside resource for their study such as Google or chatGPT.

    - Lecture Notes: Student mentions reading through the professor's provided lecture notes that accompany the weekly videos.
    - Lecture Videos: When a student mentions that they watched the weekly lecture videos as a resource.
    - Office Hours: When used as a resource implies that the student attended either the professor's or TAs' weekly office hours.
    - Practice Examlets: Professor provided practice exams (also called practice examlets).
    - Skills List: Before examlets, a recommended "Skills List" notes all the concepts and topics that a student should know and understand before the examlet.
    - Social Connections: Utilizing friends or classmates as a resource when studying.
    - Study Problems: Practice problems that are additional resources given before the examlet to help students prepare and practice their skills.
    - Textbook: The course assigned textbook for weekly reading and reference.
    - Tutorial Problems: Similar to practice problems although the answers to these problems with worked solutions are released before the examlet.
- Strategy
    - Change: This tag was utilized when a student mentioned that they altered their strategy during the semester.
    - Course Specific: When a student mentions that their studying strategies for this course are different or dissimilar from their other courses.
    - Discussion Sections: This tag was used when a student mentioned that attending discussion sections was part of their studying strategy.
    - External: When a student mentions seeking out an outside resource as a strategy for studying such as Google or chatGPT.
    - Lecture Notes: Student mentions reading through the professor's provided lecture notes that accompany the weekly videos as a specific strategy when they study.
    - Lecture Videos: When a student mentions that they watched the weekly lecture videos as a strategy for studying.
    - Office Hours: When used as a strategy implies that the student attended either the professor's or TAs' weekly office hours.
    - Practice Examlets: This tag is used when a student situated practice examlets as part of their strategy for studying and examlet preparation.
    - Problem Solving: When a student discusses or explains how they approach problems and work through the solution.
    - Self: When the student prefers to study by themselves as part of their studying strategy.
    - Skills List: When a student references consulting the Skills List as a strategy before examlets.

    - Social Connections: When a student studies in a group or uses classmates' help or guidance as a studying strategy.
    - Study Problems: This tag is used when a student situates study problems as part of their studying strategy.
    - Textbook: Used when a student mentions the textbook as part of their strategy for studying.
    - Time Management: When a student discusses the importance of time management in their studying
- Self
    - Applied: When a student discusses their preference for "applied" concepts in computer science or specifically identifies as someone who prefers "applied" concepts.
    - Background: When a student discusses their prior experiences with computer science or related fields; such as, taken previous courses in high school or participated in an internship.
    - Belonging: When a student discusses their own sense of belonging in the course or in computer science.
    - Course Expectation: This tag is used when a student is discussing their thoughts and opinions on the course prior to it starting.
    - Course Perception: When a student is discussing their thoughts and opinions on the course after it has started.
    - Mental State: When a student discusses their feelings about how they are performing in the course as well as how they felt during certain points of the semester.
    - Peer Course Interaction: When a student explains or theorizes how their peers are handling or perceiving the course.
    - Perception: This tag is used when a student is discussing or reflecting on how they are performing in the course
    - Theoretical: When a student discusses their preference for "theoretical" concepts in computer science or specifically identifies as someone who prefers "theoretical" concepts.

After the transcripts of the interviews were transcribed using artificial intelligence, the transcripts were hand-corrected against the original audio to ensure accuracy.

Results

From the 17 interview transcripts, we identified 660 tagged pieces of information for our thematic analysis. The three main themes account for most of the data and will be the focus for the analysis.

Categories	% of Utterances	# Utterances
Strategy	38.03%	251
Self	32.58%	215
Resources	27.58%	182
Exam	1.06%	7
Course	0.61%	4
Peers	0.15%	1
Grand Total	**100.00%**	**660**

Fig. 1: Percentage and Count of Utterances

I. Resources

The top two resources identified by these 17 students revolved around the practice examlets and the textbook. These two resources together accounted for 41.2% of the total tagged Resource codes. The practice examlets were tagged as a resource 40 times with students' perceptions of their usefulness was notably high; four students cited the practice examlets as the “most important” study resource. Following the practice examlets was the textbook with 35 tags; there were 11 tags of the textbook that noted it as the “main source of learning”.

Through the analysis of the 26 tagged phrases involving Social Connections, we found that students relied on their peers for homework help (seven occurrences), preferred to ask their peers for help in preparing for examlets or homework completion rather than asking a TA or the professor (five occurrences), and brought a friend with them for support to office hours (four occurrences).

The two least used resources present in this CS 173 section were, in descending order, the Skills List and the Tutorial Problems, which together represented less than 3% of the utterances. While students did not specifically cite the Skills List or Tutorial Problems as ineffective or not useful, they did not mention it with regards to their utilized resources.

Codes	% of Utterances	# of Utterances
Practice Examlets	21.98%	40
Textbook	19.23%	35
Social Connections	14.29%	26
Study Problems	8.79%	16
Office Hours	8.24%	15
Lecture Notes	7.69%	14
Lecture Videos	6.59%	12
Discussion Sections	5.49%	10
Other External	2.75%	5
Skills List	2.20%	4
External	2.20%	4
Tutorial Problems	0.55%	1
Grand Total	**100.00%**	**182**

Fig. 2: “Resource” Tag Breakdown

II. Strategy

Similarly to the “Resource” tags, the practice examlets and the textbook were the two most popular with “Strategy” tag count. Together, they account for about 27.9% of occurrences of the “Strategy” tag. This shows that there is a wider spread, or more resources represented and uttered with regards to the study habits, in the “Strategy” tag.

There were 16 occurrences of the practice examlets being present in a students’ study routine before the examlet, and within those 16, six cited the practice examlets as their “main” strategy for studying. As far as how students utilized the practice examlets, there were nine occurrences of students mentioning that they complete practice examlets until they consistently

get all the answers correct. Six students mentioned that they begin completing practice examlets a week before the scheduled examlet.

Present in the data are 33 occurrences of study strategies involving the textbook. A main theme that emerged was that students will start their study routine by reading the textbook to prepare for the upcoming week's worth of course material, and then reread the assigned textbook readings in advance of the examlet. Students sought out the textbook for clarification on how to arrange the steps in an induction proof and general vocabulary and concepts (eight occurrences). There were seven occurrences of students mentioning that the textbook is their primary strategy and main source of study.

If a prominent theme is that students are seeking out the textbook in reference on how to complete multi-step problems like proofs, it could explain the results from the problem-solving tag. There were twelve occurrences of students describing their preference to think logically about a problem, write out the steps, or consult the textbook before attempting a problem, while there were six occurrences of students describing their preference to immediately start the problem to try it out. There was some overlap as some students may opt to plan their answer before starting on some problems and on others "dive in".

Due to this course's asynchronous nature, students noted five times that the presentation of this hybrid course made their studying strategies different from their in-person only courses. Three of those five occurrences mentioned that they need to study more for this class as a result of the asynchronicity. In addition, three students noted that this course was more "theoretical" or more "conceptual" than their other courses and felt they needed to "understand the concepts more" in order to be successful.

The last noteworthy theme in the Strategy tag involved "Change". Five students shifted their study strategy after the first examlet to incorporate practice examlets in their routine; an additional three occurrences said their study strategy has shifted for every examlet due to how much they understand the concepts and working to address their doubts. Four students

mentioned that their study routine did not change from the first examlet or at any time during the semester.

Codes	% of Utterances	# of Utterances
Practice Examlets	14.74%	37
Textbook	13.15%	33
Problem Solving	11.95%	30
Course Specific	9.16%	23
Change	8.76%	22
Office Hours	6.37%	16
Lecture Notes	6.37%	16
Self	4.78%	12
Social Connections	4.38%	11
Study Problems	4.38%	11
Lecture Videos	3.98%	10
Discussion Sections	3.59%	9
Time Management	3.19%	8
External	2.79%	7
Skills List	1.20%	3

Fig. 3: “Strategy” Tag Breakdown

III. Self

Keyword tags with “Self” were second in utterance count to “Strategy”; the former having 215 and the latter 251. Within these 215 utterances, two themes emerged in the “Course Perception” tag. The most frequent was 19 occurrences of students mentioning that this class was more difficult than they had initially anticipated and that the students were performing more poorly than expected. Despite these high numbers expressing difficulty, there were 11 occurrences of students mentioning that they “enjoyed” the class.

Related to these findings seemed to be congruent with the results of the 29 “Belonging” tags. There were 12 utterances that completing CS 173 increased the student’s sense of belonging in computer science with five students citing the difficulty of the course as a main reason. To elaborate, these five students mentioned that due to the conceptual nature of the course and the material, rising to the challenge and passing the course increased their sense of belonging. It is important to contextualize that there were nine occurrences in the “Belonging” subtag that mentioned this course did not positively or negatively impact their sense of belonging. Five of these occurrences went on to elaborate that other courses, previous experience in high school, or internships was more impactful regarding their sense of belonging in computer science.

The “Course Expectation” subtag was a broad one applied to two categories: the interest level of the student in the material and then predictions of the effort needed. There were 10 occurrences of students mentioning that the course and its material would be interesting and there were 12 occurrences from students, before the course started, thought they would do well. Occurrences mentioning negative predictions for course outcomes were much lower at only four.

The final large theme from these interviews came from the subgroup of “Mental State” with 13 occurrences of students mentioning that during the duration of the course, they felt anxious either about assignment completion or about grades on the examlets. Seven went on to mention that the weeks they had examlets to study for made them even more anxious.

Codes	% of Utterances	# of Utterances
Course Perception	24.65%	53
Course Expectation	20.00%	43
Perception	13.95%	30
Belonging	13.49%	29
Background	9.30%	20
Mental State	7.44%	16
Peer Course Perception	4.65%	10
Applied	1.86%	4
Motivation	1.40%	3
Theoretical	1.40%	3

Fig. 4: “Self” Tag Breakdown

Discussion

To understand the relationship between the resources and strategies that students use to study, their sense of belonging, and their earned grades, in part we used a qualitative research method called thematic analysis to discover patterns in our interview data. Our team is also using quantitative analysis to provide additional insights and gauge the statistical significance of our findings.

In the “Resources” tag, the “Textbook” subtag produced an informative theme that many of the students were citing the textbook as an important, integral part of their studying routines and strategies. In contrast, Chinn et al (2010) observed 34/94 students mentioning the textbook as their “most useful” resource. Our population mentioned the textbook with a higher proportion of positive reviews. Further showing the prominence of the textbook, several students

mentioned that the textbook is the first resource they use to learn a new module, reread the textbook prior to examlets, and refer to the textbook for concepts and proof demonstrations.

The two most cited strategies represented in this dataset involved the use of the textbook and practice examlets for studying and examlet preparation. These two themes could lend insights into the students' perception of the importance of understanding the course concepts and how they will be assessed. A few students noted that they would complete practice examlets until they received all correct answers. This strategy could suggest that students may need multiple exposures to a certain problem type before they feel comfortable and confident demonstrating mastery.

Referencing the "Self" tag and the "Belonging" subtag, there may be evidence that there could be a balance between difficult content that leads to increased sense of belonging. This appears to be in line with Veilleux et al (2013) that a students' perception of their own abilities may be more influential to their feelings of belonging than their measurable skill set. If a student is able to keep pace with the CS 173 course and earn a grade they are satisfied with, perhaps they are more likely to report an increased sense of belonging in computer science.

Conclusion

We sought to test and extend the findings surrounding resource utilization, belonging, and student outcomes in a hybrid computer science course at the University of Illinois. For the thematic analysis, we found that there is evidence that the textbook and practice examlets are important resources that students may choose to use. They are present in studying routines and strategies for preparing for examlets. Based on the insights from the Spring 2023 cohort and our thematic analysis, we recommend to future CS 173 students to endeavor to include the textbook and practice examlets in their study routine and begin studying at least three days in advance of examlets. The former cohort expressed their advice to understand the concepts thoroughly,

which may have driven them to adapt their certain routines and for some, increased their sense of belonging.

In asynchronous and hybrid courses, there may be different learning strategies and resources that students employ as they may work through material more on their own than in a traditional in-person lecture. There needs to be more studies to fully understand this selection process as well as its impact on final grades and motivation. Our study had some limitations as this was a small sample size of 17 students. For a future iteration of this study, we would like to include more students from future cohorts to capture more nuance and perspective to inform our analysis. We may also seek out students who are further along in their college career to reflect on their time in CS 173 to have a longitudinal perspective on the impacts of this course.

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