Qualitative Analysis of Student Responses to Metacognition Prompts in College Algebra

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Students in a college algebra course completed reflective metacognition journal assignments about their studying and performance in the course. This paper is a thematic analysis of the qualitative data collected from those journal assignments and surveys about the effects of the journal assignments on their studying and performance in the course. We investigate how the journal assignments affected the study strategies they used in college algebra and what students learned about themselves as learners through these reflective assignments. Findings indicate that metacognition journals were effective in supporting students in reflecting and changing their study habits. Qualitative analysis is used to describe students' reflection and changes to study habits after engaging with journals embedded in a mathematics course.

Keywords: College Algebra, Metacognition, Developmental Math, Qualitative Analysis

The first year in university can be challenging for students academically. First year courses traditionally have higher rates of student failure or withdrawal and have a direct impact on student retention and degree completion overall (Flanders, 2017). Developmental mathematics courses like college algebra, which often do not serve to meet a degree requirement but rather prepare students for further university level mathematics courses, are no different (Tunstall, 2018). To support students in successful completion of college algebra researchers and instructors at several institutions have worked to redesign the course to include more active learning methods, revised curriculum, and innovative pedagogical approaches like modeling-based learning (Tunstall, 2018; González-Muñiz et al., 2012). While these reforms show promise, there is still work to do in supporting students in understanding mathematical concepts during a critical course in their first year at university.

One approach to improving student learning in mathematics is through supporting self-directed learning via metacognition. Metacognition is defined as "thinking about one's own thinking" or awareness or analysis of one's own learning or thinking processes (Tanner, 2017; Flavell, 1979). Although several frameworks exist to understand the process of metacognition, we conceptualize metacognition to include the skills of goal setting or planning, monitoring progress, and evaluating performance (Lovett, 2011; Tanner, 2017). While we know that acquiring and practicing these skills are critical to student performance in mathematics (Verschaffel et al., 2017), many students enter their first year of university without direct instruction or experience with planning, monitoring, and evaluating their mathematics learning. Within STEM, one approach to improving student learning is through incorporating metacognitive instruction alongside academic content within the course itself (Lovett, 2011; Tanner, 2017; Colrthorpe et al., 2019). These metacognitive supports may include reflection on learning through exam wrappers (Lovett, 2011), discussion prompts (Colthorpe et al., 2019), and questionnaires (Lucangeli, et al, 2019). These approaches are appealing to educators since "... metacognition continues to be a predictor of mathematics performance" (Desoete & De Craene, 2019, p. 556) and their implementation are a brief and manageable addition to a course for both instructors and students (LaCaille et al., 2019).

In this study metacognition journal assignments were embedded throughout a college algebra course. Students completed seven journals and a post survey regarding their experience with the journals. In this paper we analyze responses from one journal and the post survey. As we examined these student responses, we sought to answer the following research questions.

1. [RQ1] Did students report changing their study habits due to metacognition journal assignments? If so, how?
2. [RQ2] How do students define a productive study session? What can we learn from this about their study habits in college algebra?
3. [RQ3] What did students learn about themselves through metacognitive journaling in college algebra?

Methods

Metacognitive Intervention

The college algebra course was incrementally redesigned between 2020 and 2022. One of the key changes was the addition of metacognition journals to the course. These metacognition journals were graded assignments; students received full credit once they completed a journal assignment. There were seven metacognition journals throughout the semester and together made up 4.2% of the final grade. As part of the course redesign process, students were given surveys at the beginning (pre-surveys) and end of the semester (post surveys) to assess the effectiveness of the course changes. Beginning in Fall 2022, students who completed the surveys were asked to consent in a research study that would allow their survey responses, their course grades, and coursework to be analyzed. (They did receive bonus points for completing the pre and post surveys.) In this paper, we are analyzing and discussing responses of study participants on one of the metacognition journal assignments and questions from the post survey. This study was conducted over three semesters: Fall 2022, Fall 2023, and Spring 2024.

Data Collection

In Fall 2022, 473 of 754 students enrolled in the course (62.7%) participated in the study. The Fall 2023 semester had 538 of 672 students enrolled (80.1%) participating in the study. Enrollment in this course is much lower in the spring semesters. In Spring 2024, 107 of the 133 enrolled students (79.2%) participated in the study. Thus, the study had 1,118 participants.

The post survey asked students specific questions about the metacognition journals. One question asked students which of the metacognition journals was the most useful for them. According to this question, Journal 2 was the most helpful, and it is for that reason that we chose to analyze students' responses from that journal assignment. We also analyzed responses from two questions about metacognition journals from the post survey.

Coding and Analysis

Journal responses were coded through an iterative and collaborative process with three researchers. An inductive and comparative method (Mirriam & Tisdale, 2016) was used to develop themes from the data. During the first round, open coding (Saldana, 2016) was used by two researchers to develop initial codes. The researchers then refined those codes, coming to an initial agreement on definitions. These codes were tested on a sample of student responses and researchers met again to check coding agreement and utility of codes. During this second round of coding, definitions were refined and additional codes added when needed. A third and fourth round of sample coding was performed until agreement between researchers was reached on all

codes. The remaining student responses were then coded by a single researcher. After all responses were coded, researchers engaged in thematic analysis (Glesne, 2018) of student responses. Themes were developed by researchers through analysis of patterns within the coded data.

Data and Results

Journal 2

During the second and third week of the semester, students were asked to log when they studied for their college algebra course. Between the two weeks, students were given information about spaced practice and how it is shown to be more effective than studying all at once. After two weeks, students completed the metacognition journal assignment. We are investigating the open-ended responses students submitted on that assignment about how the classify productive study sessions and the changes about their study habits.

Productive study session. Students responded to the prompt "How do you define a 'productive' study session?" We created fifteen codes that were grouped into five themes.

1. Environment. This theme includes whether people studied alone or with others and the level of distractions within the environment.
2. Outcomes. This theme is characterized by what students finished in the study session; for example, did they learned something new, complete a task, or work efficiently?
3. Planning. This theme includes codes scheduling time to study or making lists of tasks to complete during their study sessions.
4. Self/Affective. This theme includes codes that describe students' ability to focus during a study session or feeling confident after the study session.
5. Study Habits. This theme is characterized by the types of study methods students used during a study session, e.g. explaining concepts to others or reworking examples.

The 1,116 responses produced 2,091 codes. To avoid double counting responses that contain two codes from the same theme, we are reporting the percentage of codes instead of percentage of responses. Figure 1 shows the percentage of codes for each of the above themes.

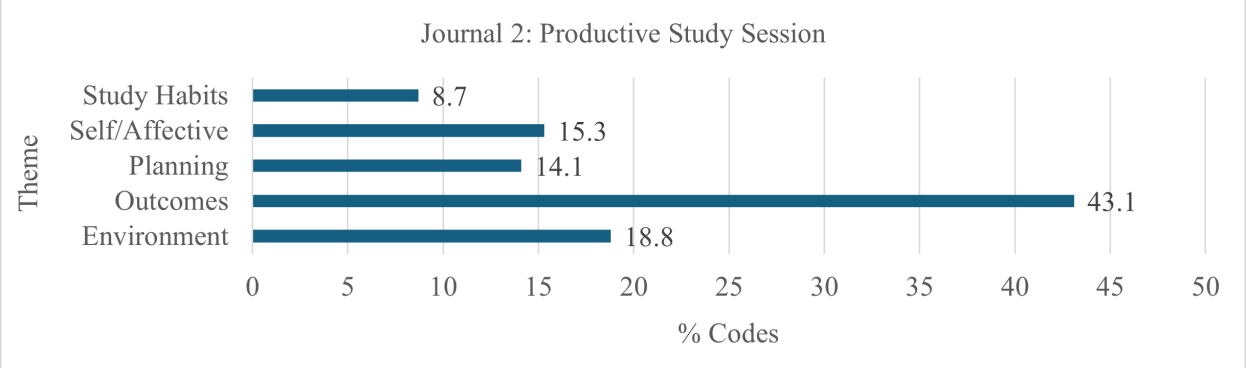

Figure 1. Theme vs. % Codes from Journal 2: Productive Study Session.

Study changes. Students responded to the prompt "Reflect on what we discussed in class about metacognition and what you discovered in the last couple of weeks about how you study and learn effectively. What changes will you make to your study strategies? What study strategies will you continue?"

We created twenty codes and categorized the codes into four themes.

1. Environment. This theme includes codes related to where students will study, how they will reduce distractions, and whether they will study alone or with a group.
2. Evaluating. The only code in this theme is "evaluating/reflecting" and was used when a student mentioned reflecting periodically on their study skills to see if they want to make additional changes.
3. Planning. Codes in this theme relate to students planning when they would have a study session, including if they intend to do spaced practice, or planning what topics they will cover in a study session.
4. Study Habits. This theme is characterized by study practices or habits students will use in the course. Habits range from general best practices like attending class to specific study skills like rereading notes or self-quizzing.

There were 1,117 responses which produced 2,182 codes. The percentage of codes for each theme is displayed in Figure 2.

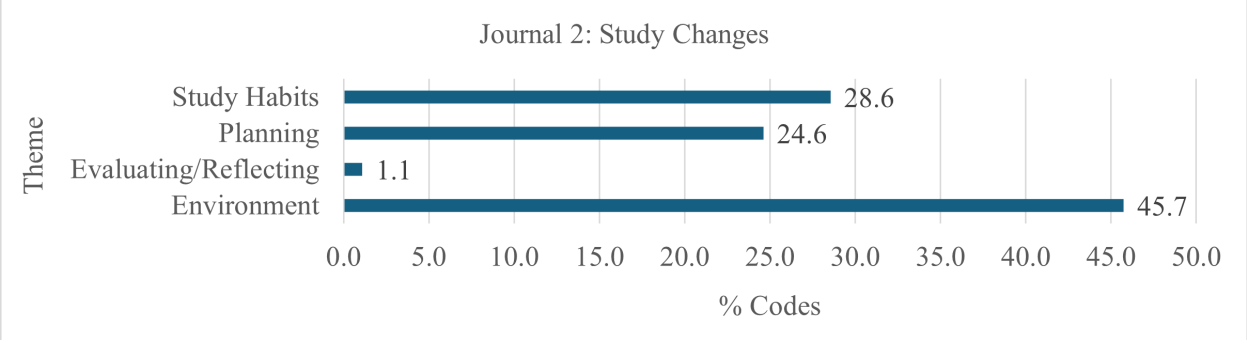

Figure 2. Theme vs. % Codes from Journal 2: Study Changes.

End of Semester Survey

At the end of the semester, students were invited to complete a post survey that included questions about their self-efficacy, their mathematical anxiety, and general course questions. The questions on self-efficacy and mathematical anxiety were direct parallels to questions asked during the pre-survey to track their progress over the semester. This line of inquiry is being explored within the same data (Preschel, 2025) but is outside the scope of this paper. The post survey included multiple choice and open-ended questions about students' experience with and the effects of metacognition journals.

Self as learner. We coded student responses to the prompt, "What (if anything) did you learn about yourself as a student through these metacognition journal assignments?" We generated a total of nineteen codes and grouped them into five themes.

1. Planning. This included codes where the student mentioned future-oriented practices like setting goals for a study session or a course.
2. Self/Affective. This theme included codes that referenced internal aspects of the student. Examples include mentioning how well they focus or that they learned something about how to motivate themselves.
3. Study Habits. This theme included codes that referenced habits, tools, or actions that would aid them in study, (e.g., using outside resources, or trying a new study skill.)
4. Evaluating/Reflecting. This theme included codes that showed students learned either to diagnose which material they needed to study or to reflect on how their studying was going.

5. Did not learn anything. This theme was a singular code where students mentioned that the journals did not provide them with anything.

This prompt provided us with 1118 responses with 1020 codes. See Figure 3 for the percentage of codes in each theme.

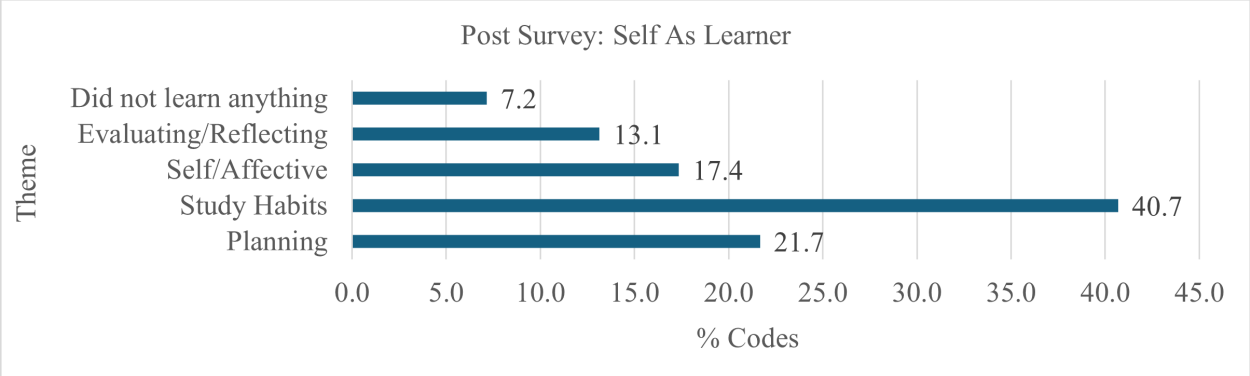

Figure 3. Theme vs. % Codes for Post Survey: Self as Learner.

Study changes. Students were asked to "Describe any changes you made to your study habits because of the metacognition journal assignments." A total of twenty-seven codes were sorted into five themes.

1. Environment. This included codes related to external factors to the student and the environment they studied in.
2. Planning. This included codes where the student mentioned future-oriented practices that do not occur within the moment of studying.
3. Study Practices. This included codes that pertained to actions that occurred while studying or events/actions that were considered studying.
4. Self/Affective. This theme included codes that referenced internal aspects of the student. Examples include increased confidence or activities to reduce stress.
5. Study Habits – General. This theme was for codes that gave vague statements about study habits that were not as specific as other themes (e.g., "No change" or "I changed my habits").

This prompt provided us with 1118 responses with 1101 codes; the percentage of codes in each of the five themes is in Figure 4.

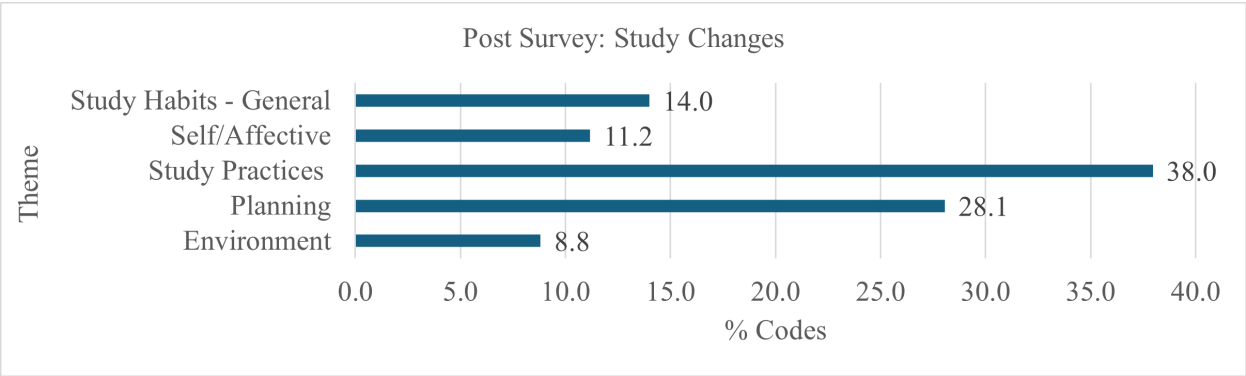

Figure 4. Theme vs. % Codes for Post Survey: Study Changes.

Discussion

Journal 2

In the discussion that follows, percentages reported for themes will indicate the percentage of total codes for the prompt, while percentages for reported codes will correspond to the percentage of student responses with that code.

Responses to the Journal 2 Productive Study prompt, which give insight into RQ2, fell into five thematic categories: Environment, Outcomes, Planning, Self/Affective, and Study Habits. The most prominent theme was "Outcomes" at 43% of coded entries. (See Figure 1.) The highest occurring codes in this theme were "Complete a Task" (40%) and "Understanding/Learning" (37%). While these two codes may provide students with a sense of productivity in their study session, we questioned if these measures indeed align with student learning. The least frequent theme, "Study Habits" (9%), included study habits that would give more concrete measure of student learning, including the codes "Retrieval Practice" (4%) and "Explains Concepts to Others" (2%). These practices would provide students with more direct measure of their learning but were much less frequently reported by students as part of a high-quality study session. Related, the theme "Self-Affective" (15%) reveals that students often rely on "Feeling Confident/Good" (8% of responses) or being able to "Focus" (20% of responses) as an indicator of a productive study session. As we know novice students frequently overestimate their skill or feel overconfident, this may or may not be associated with increased learning. Further, "Focus," without attention to high-impact study strategies, like reading over notes versus retrieval practice, may or may not align with learning. Lastly, we see that students often look to their "Environment" with 32% of students reporting "Limiting Distractions" as how they measured a productive study session.

For the Journal 2 Study Changes prompt, students described changes they would make to their studying after monitoring their habits for 2 weeks. Since this journal was assigned at the beginning of the semester, the responses give us a baseline measure for RQ1. The most frequent change reported by students was the theme "Environment" (46%) which included the codes "Remove Distractions" (35.5%) and Location (34.7%). Students understood the importance of the environment in relation to their studying after reflecting on their study sessions. Furthermore, students perceived the study environment as a significant barrier to their studying, and they planned to improve it by intentionally limiting distractions or moving to a location more conducive to studying. The second most frequent theme was "Study Habits" (28.6%) which included codes related to study habits students noted were useful in their studying including "Increasing Study Time" (8.8%), "Working/Practice" on problems (8.6%), "Taking Breaks" (6.7%), completing "Assignments" (8.3%), and "Office Hours" (6.1%). While adoption of these practices is positive, high impact study habits like "Spaced Practice" and "Retrieval Practice," were less frequently reported by students. Finally, "Planning" (25%) was another common theme within student responses. Students reported planning the time that they studied (19.2%), spacing out the timing instead of cramming (21.6%), and planning what they worked on during a session (2.1%) were all changes they would implement after monitoring their study sessions. Responses to the Post Survey Study Changes prompt indicate how successful students were in continuing these habits.

Post Survey

As noted in the Results, the most prominent theme for the Post Survey Self as Learner prompt was "Study Habits" with 40.7% of coded entries. This theme included responses where

students mentioned they "Learned to Study Effectively" (14.3%) or referred to their "Study Habits" (14.7%) or "Study Frequency" (4.5%). These findings address the second part of RQ1 ("If so, how [did their study habits change]?") by showing that students described their changes with increasing specificity. Many codes within this theme also carried an evaluative component. For example, "Time Management" (7.8%) included responses where students said they were good at time management or needed to improve. This not only helps to answer RQ3, but it shows students are identifying their strengths and weaknesses regarding study skills. While responses to the Post Survey Self as Learner prompt highlight students' broad perceptions about their study skills, the second prompt from the post survey offers a more detailed view of the specific changes students reported making.

The codes for the Post Survey Study Changes prompt provide insight into how students' study practices varied and what outcomes emerged. The three most frequent codes, each clearly separated from the rest, were "Increase Study Time" (11.2%), "Studied Earlier for Exams" (10.9%), and "Spaced Practice" (10.4%). These fall into two different themes: Planning ("Spaced Practice" and "Studied Earlier for Exams") and Study Practices ("Increase Study Time"). Overall, the themes "Study Practices" (38%) and "Planning" (28.1%) were the most common themes. This suggests that students not only adjusted the concrete ways they studied but also developed stronger planning strategies to support those habits.

In relation to RQ1, the Post Survey themes and codes added both detail and precision, while opening avenues for future inquiry beyond the scope of this paper. For example, future analysis could examine student outcomes associated with codes, explore connections across codes, prompts, and themes, or trace temporal patterns of change across the semester. Future work could investigate how to strengthen support for students. For example, a support that was implemented in this course (but its study was outside the scope of this paper) was Metacognition Mentors. Additional considerations could include adapting prompts and support to align more closely with the study habits revealed in this project.

Conclusion

Together, these findings suggest that the metacognition journals effectively introduced students to metacognitive practices and encouraged reflection on those practices. At a base level, 93.5% of students stated they learned something about themselves as learners through the metacognition journals. The responses show that students are beginning to think about what helps them learn best. However, students may not be good at evaluating how well they truly understand a concept. For example, students measured productivity in a study session by focusing more on finishing tasks, their environment, and how they felt while studying. Not surprisingly, when students planned on making changes, they primarily focused on removing distractions with a secondary focus on the study habits they implemented. At the end of the course, when students reflected on the study habits they changed, they were most likely to mention more time studying, study earlier for exams, and include more spaced practice. The frequent mention of spaced practice shows growth in students' awareness about high-impact study practices. Their end of course reflections also indicate that students knew what appropriate study habits for themselves would be, even if they did not meet their own expectations. Thus, it is important for instructors to discuss and model effective study practices and encourage students to continue to reflect and try new strategies.

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