

## Metacognitive knowledge and regulation of peer coaches

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Peer coaches are undergraduate peer educators who help facilitate learning in introductory STEM classes, either as learning assistants or peer-led team learning leaders. Peer coaches' facilitation is generally focused on specific content knowledge, but their pedagogical skills could be applied to other content, such as metacognition. Metacognition, an individual's awareness and management of their own thinking and reasoning, is an important skill for undergraduate students to learn, though these practices rarely receive the explicit focus required for their development. Peer coaches could act as facilitators of metacognitive practices with their introductory STEM students. As a first step to investigating this potential role, we collected and analyzed written artifacts from the peer coaches' pedagogical training course, looking for evidence of metacognitive competence. We found that coaches had competence in metacognition both as a learner and as a coach, and that these two perspectives informed each other in productive ways.

## I. INTRODUCTION

The ever-present call for better learning environments and educational gains for undergraduate STEM students has led to the development of different types of undergraduate-facilitated peer learning. Peer coach facilitators are advanced undergraduates who support active learning in introductory courses. There are several kinds of peer coaches, including learning assistants (LA's) who facilitate learning during classtime alongside professors [1], and peer-led team learning (PLTL) leaders who facilitate learning in small-group sessions outside of normal class hours [2]. These two models have similar goals and outcomes. Peer coaches improve student learning outcomes and interest in their specific topics [1–4]. Other benefits to peer coaching include stronger scientific subject identity in their students and greater retention in science and education majors [1–6]. Peer coaches receive training from a semester-long pedagogy course and weekly preparation meetings with faculty members and senior leaders, ensuring they are prepared to support their students' learning, problem-solving, and group work.

Learning about metacognition is a recommended part of peer coach pedagogical training [7, 8]. Metacognition describes knowledge and awareness of one's own cognitive processes [9], a definition that has expanded in recent literature to also include knowledge of specific problem-solving practices and the ability to discern their proper use [10]. Implementing metacognitive practices has been shown to help students by developing higher-order thinking skills, scaffolding of self-regulation, and bolstering motivation for future learning [11, 12], which improves final grades for students [13].

Despite the learning benefits of metacognition, and in contrast to the peer coach pedagogy class, explicit instruction of its practices to students in STEM classroom settings is rare [14, 15]. In the effort to improve student metacognitive practice, we investigated if instructors could productively enlist the help of peer coaches. That is, can peer coaches be effective metacognitive coaches?

Previous studies have investigated similar questions. Lutz and Rios [16] explored LAs' epistemological growth toward seeing knowledge as co-constructed, which is a foundation for productive metacognitive practices. Another study investigated student metacognitive outcomes when peer tutors were enlisted to support metacognitive growth [17]. Our work will focus on the peer coaches' preparedness to act as metacognitive coaches, which has not yet been explored.

## II. THEORETICAL FRAMEWORK

The framework of STEM teacher knowledge guides our thinking about what it would mean for peer coaches to be metacognitive coaches. This framework posits three facets of teaching knowledge: pedagogical knowledge, content knowledge, and pedagogical content knowledge (PCK) [18, 19]. The latter is an instructor's specialized knowledge of both

content and educational strategies that work best for teaching their specific subject. Previous studies on LAs [20] and PLTL leaders [21] show evidence that peer coaches develop general pedagogical knowledge as part of their facilitation experience. This study focuses on peer coaches' content knowledge, where the specific content is metacognition. Peer coaches' PCK about metacognition will be left to future work.

Content competence related to metacognition is conceptualized as composed of two subcategories: metacognitive knowledge and metacognitive regulation [10]. Metacognitive knowledge consists of 1) declarative knowledge about the concrete concepts and practices one knows, 2) conditional knowledge about when and why specific practices should be used, and 3) procedural knowledge about how to implement and manage these practices [10]. Metacognitive regulation consists of 1) planning done prior to cognition in the selection of practices, 2) monitoring one's awareness and comprehension during a cognitive task's completion, and 3) evaluating one's processes and products after cognition for potential improvements [10]. Peer coaches can engage in all of these facets in their roles as learners and coaches. We define metacognitive competence as having both metacognitive knowledge and metacognitive regulation.

Our research questions for this preliminary study are: 1) What metacognitive knowledge and regulation do peer coaches exhibit in their role as learners? 2) What metacognitive knowledge and regulation do peer coaches exhibit in their role as coaches? and 3) How does metacognitive competence in one role inform competence in the other role?

## III. METHODOLOGY AND DATA COLLECTION

This study took place at the University of New Hampshire, where the peer coach program serves the introductory STEM courses, with LAs working in physics and mathematics and PLTL leaders working in biology, chemistry, and neuroscience. For their first semester in the program, all peer coaches take the same one-credit pedagogical training course, which focuses on the pedagogical strategies and metacognition they will practice in their new role. The first author, a graduate student of the institution, helped modify and deploy the course and associated materials. The second author is one of the two professors who taught this course over the last 15 years.

In the course there were two class meetings focused on metacognition. The first set of readings [23–25] describe in detail specific implementations of metacognitive practices. Students read one of these papers and then shared their insights through a jigsaw [26] activity with their peers. The second week's reading was a compilation of cognitive science research on ten easily implemented metacognitive strategies [22]. In class, the peer coaches discussed each strategy, including when and why it should work.

We collected all written assignments from the pedagogy course from those peer coaches who consented to partici-

TABLE I. Description of written artifacts collected from peer coaches' pedagogical training.

Data Name	Prompt
Synthesis Paper	1) A status report on your progress as a facilitative leader. Speak particularly to how you may have change or evolved in your actions or thinking. In particular, I want you to reach to incorporate ideas from any theories or research on student learning that we read about or discussed. 2) How participating in this course and having this experience has affected your own learning in other courses. This is about YOU as a student, NOT in this pedagogy course
Reflection on Metacognitive Readings	Q1: Which reading did you do? Q2: What was something new in this reading for you, and why did you find this interesting or important? Q3: Give details about how some part of this reading connects to your previous beliefs and/or experiences. Q4: Ask an "I wonder" question.
Self-report of Effective Study Strategies	Q1: What is one study strategy that works well for you and how/why does it help you? Q2: What is one study strategy that hasn't worked for you and how/why didn't it help? Q3: How do you know when you know something? For example, when do you feel confident that you understand a metabolic pathway, or a chemical reaction, or a mathematical proof, or a physics problem solving strategy?

pate in the research, for a total of four semesters beginning in Fall 2021. We focused our analysis on those artifacts that were tied to the concepts of metacognitive practices. Table I provides a description of these artifacts and the associated prompts given to peer coaches to generate them. For this study, we selected two peer coaches to serve as case studies, so that we could look in detail at individual coaches using all the data in Table I. Both coaches attended the pedagogical training course during the Fall 2022 semester and were seen as typical of the population because they showed metacognitive competence both as learners and coaches, with some overlap of these two roles. The two coaches we selected for further analysis will be referred to as Ava, an LA, and Stephanie, a PLTL leader.

Our initial analysis, which was conducted in the fall of 2022, focused on the synthesis papers written by the peer coaches during the prior semesters, as these were generally the most detailed and thoughtful writings. We began with a set of a priori codes from the literature about metacognitive competence of learners (declarative, conditional, and procedural knowledge, planning, monitoring, and evaluative regulation). As we coded collaboratively, we developed inductive codes that captured themes not present in the a priori codes. We found that the coaches were frequently being metacognitive in their role as coaches in ways that were distinctly different from metacognition as a learner, so we created specific codes for these roles. Furthermore, coaches sometimes reflected on how regulation in one role informed their actions in the other role: we created a code for this named "interplay". Lastly, we realized that the initial categories were too fine grained for our needs, and focused simply on the broader categories of metacognitive knowledge and regulation.

For our analysis, we applied the a priori and inductive codes used in the initial analysis to the written artifacts collected from Ava and Stephanie, with a focus on finding instances of metacognitive competence.

#### IV. ANALYSIS

Through our analysis, we categorized instances of peer coaches' metacognitive competence around five key features. These are metacognitive knowledge and metacognitive regulation, each from both the perspective of a learner and the perspective of a coach, along with the interplay between these two perspectives.

##### A. Learner Metacognitive Knowledge

We define learner metacognitive knowledge as a peer coach's knowledge of learning strategies that utilize higher-order thinking skills, including how to use these strategies themselves, when to use them optimally in their learning, and why they are effective for their learning. Peer coaches' learner metacognitive knowledge can come from their own experience as learners and their pedagogical training. We have seen evidence of this throughout the written artifacts collected, with both Ava and Stephanie making mention of multiple study strategies they utilize when studying for their own classes:

- Group Work
- Practice Testing
- Flashcards
- Vocalization
- Self-Explanation (how is new information related to old information, explaining steps in problem-solving)
- Summarization
- Rereading/rewriting notes
- Chunking (breaking down difficult tasks to smaller tasks)
- Imagery to Text

These strategies are detailed in two of their readings for the pedagogy course [22, 25]. The two peer coaches demon-

strate their knowledge of many strategies, going significantly beyond the common strategies of re-reading and highlighting [22], suggesting a strong foundation for metacognitive competence.

The peer coaches show further learner metacognitive knowledge in their understanding of the use and effectiveness of these study strategies. For example, Stephanie responded to a metacognitive reading [22] with the following:

Something new I learned from this reading was the process of learning and how rereading something over and over again is not the correct way of learning, I found this very important because that's how i've been studying for my exams by cramming in the material by rereading lecture slides in which did not help me in the long run.

Stephanie's learner metacognitive knowledge allows her to recognize strategies like rereading and cramming, as well as judge them for her own learning and adjust accordingly. She demonstrates the active processes of utilizing content knowledge of metacognitive regulation, which is indicative of metacognitive competence.

### B. Coach Metacognitive Knowledge

We define coach metacognitive knowledge as a peer coach's knowledge of classroom facilitation strategies and pedagogy, which includes what strategies are effective for a specific topic, when students can best utilize them, why such strategies are effective in different contexts, and the peer coach's individual philosophies about facilitation. Both Ava and Stephanie wrote about metacognitive practices they have seen within the context of coaching, including:

- Group Work
- Practice Problems
- Elaborative Interrogation (explaining why something is true)
- Chunking
- Visualization

This list shows the familiarity that peer coaches have with metacognitive practices that occurred during coaching. These discussed strategies were either observed in students' behavior or introduced by the peer coaches. Their discussion of these strategies demonstrates their ability to recognize practices regardless of origin, and therefore demonstrates their coach metacognitive knowledge.

We see additional evidence of coach metacognitive knowledge as our peer coaches discuss the implementation of these known strategies in their coaching sessions. For example, when speaking on the decision to include more visual components to her problems, Stephanie writes:

[H]aving something visual to plan out and followed really helped my students who like to have something to look at while solving a problem and

if they did encountered something similar on a homework problem or a question on an exam they can visualize back to our activity and remember the steps on how to tackle it.

Here, Stephanie shows her coach metacognitive knowledge by drawing a connection between the learning strategies she can facilitate in her sessions and their benefits to her students. Peer coaches demonstrate metacognitive competence through not just knowledge of metacognitive practices, but of the pedagogical implications during the coaching experience.

### C. Learner Metacognitive Regulation

Learner metacognitive regulation is a peer coach's active thoughts and behaviors relative to learning and performance on cognitive tasks. This includes planning with consideration for familiarity and interest in the topic, monitoring for actions and behaviors that promote or deter learning, and evaluating work from the context of a course and one's goals. Learner metacognitive regulation can be seen when peer coaches reflect on their active learning behaviors over a semester. For example, when Ava talks about her use of practice problems to study for her introductory physics course, she says,

Not only was it easier to memorise the formulae and apply them, but also the theory started to make more sense. I consciously understood the best study strategy for me and worked on areas that I found difficult.

Here, Ava engages in learner metacognitive regulation by actively monitoring her progress in a new study strategy, then evaluating its effectiveness so that it can be better tuned to her needs as a learner.

### D. Coach Metacognitive Regulation

Our definition of coach metacognitive regulation is a peer coach's active facilitation strategies and behaviors. This includes planning instruction around both content and pedagogy, monitoring their facilitation's effectiveness through the responses from student learning, and evaluating the impact of their facilitation strategies based both on student assessment and personal reflection. We found evidence of coach metacognitive regulation in the peer coaches' work with their students, such as when Stephanie responded to a reading assignment focused on cooperative learning:

Group effort, there is a saying that a group is as strong as the weakest link. I'm not saying that a person is dragging the group down but they should help a group member who is having a hard time with the topic or subject and from that rewards the student with extra credit and from there reflects their own individual goals and I see

that a lot with my own pltl group because when I split them into groups to work with each other they help each other out it one student doesn't understand something they try to help the student understand.

This excerpt demonstrates Stephanie's coach metacognitive regulation: she monitors how her students' learning aligns with both the teaching strategies she implements and her own attitudes towards them. Her regulation of her facilitation happens during the students' work in her PLTL sessions and before in her preparations for the session's structure. Stephanie actively and continually take steps to bolster student learning outcomes, a direct result of her metacognitive competence.

### E. Interplay of Perspectives

While peer coaches have been shown to act as either a learner or a coach within a given situation, their positioning between these two perspectives means that they can overlap, resulting in beliefs and attitudes unique to both. We refer to this as interplay of perspectives, which we define as the influence that one perspective of a peer coach has on another perspective. We see evidence of this when peer coaches discuss how their implementation of coaching strategies impacted their own learning. For example, when speaking on the benefits of group work, Ava wrote,

As I watched my students work together and facilitated their group work, I realized that even the student at the top was able to learn from the experience. By helping their group members, they were able to articulate their thoughts and solidify their own understanding of the material being taught. As a result, not only did I push my students towards working in groups, I tried to implement the strategy into my own study methods.

Here, we see Ava reflecting on the benefits provided to her own students by using the learning strategy of group work and deciding to use it herself as a learner. This is more than simply an instance of "practice what you preach," as Ava engages in metacognition to analyze the positive outcomes seen in coaching and understand how she, as a learner, could improve her learning with them.

We also see interplay of perspectives in the reverse situation, where peer coaches talk about how their experiences as learners affected their coaching strategies. This can be seen when Stephanie, reflecting on an assigned reading outlining specific metacognitive practices [22], writes,

[T]his paper was very useful and helpful in the way I view my own study strategies but also gave me insight in how many different ways my students study for their own exams as well.

From this quote, it seems possible that because Stephanie saw the value of the strategies for her own learning, she was more

likely to extend the value of those strategies to her students. A peer coach's ability to metacognitively reflect on their own learning can provide great insight into the practices that might benefit their students, enabling a stronger coaching experience.

## V. CONCLUSIONS AND DISCUSSION

This pilot study shows that our two peer coaches demonstrate several aspects of metacognitive competence. This includes metacognitive knowledge and metacognitive regulation, both from the perspective as a learner and as a coach, along with the interplay of these two roles. Evidence of these facets of metacognitive competence was seen in the written artifacts from their pedagogical training course, where they spoke on their experiences from both roles over their first semester.

We have seen similar evidence in other peer coach reflections as well. In future work, we will analyze the remainder of the data set (N=127) to look for further evidence of metacognitive competence. We will also focus on the uniquely powerful interplay of perspectives, and seek evidence that this interplay allows for peer coaches to experience increased metacognitive growth compared to an individual holding only one such role.

Building from this work and the literature, we will go beyond the current research to construct an fuller operational definition of a metacognitive coach (which will include metacognitive competence and interplay as core components of facilitating metacognition) and analyze the data from the full set of students to investigate to what extent our peer coaches are metacognitive coaches. Other characteristics which we will investigate include the peer coaches' ability to be explicit about their metacognitive competence and to tie the formal readings to their own experiences; both of these characteristics indicate deep understanding [27, 28]. We have also seen hints of pedagogical content knowledge [19] about teaching metacognition. For example, some peer coaches show an awareness of unproductive but common metacognitive practices, and others show a belief that metacognition should be explicitly taught.

The end goal of our work is to inform classroom practices both in the pedagogy course and in the peer coach interactions with students. Future work could investigate which readings and reflection prompts in the pedagogy course are effective for developing productive coach practices and peer coaches' deployment of metacognitive interventions with their students.

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