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Secondary Teachers' Implementation of Metacognition and Interpretation of Student Metacognitive Knowledge and Regulation

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Abstract

Metacognition has been shown to be important in the learning process of students. However, teacher awareness and understanding of metacognition seems to be limited. In this study, we use an interpretivist approach to explore how secondary teachers facilitated learning and perceived metacognition after participating in professional development on metacognitive strategies. First, we present themes that emerged from the in-depth interviews for how participants progressed in their operationalization of metacognition. We then present rich descriptions on a per-participant basis of how teacher-participants' views of metacognition changed over time. Next, we present conclusions, including teacher-participant troubles with operationalizing metacognition. Finally, we propose a revised Model of Teacher Change accounting for teacher-participant experiences undergoing professional development on a complex topic (i.e., metacognition).

Keywords: metacognition; teacher beliefs; student thinking; project-based learning

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Introduction

Albert Einstein once said, "Education is what remains after one has forgotten what one has learned in school" ("Albert Einstein Quotes," n.d.). While the importance of students thinking deeply about subject matter is often a source of tremendous focus for educators, they may over-assess their knowledge of, and implementation of, metacognitive concepts such as self-regulated learning (Spruce & Bol, 2015). Metacognition, a concept related to academic achievement and success (An & Cao, 2014; Burton, 2012; Gourgey, 1998; Pate & Miller, 2011; Wang et al., 1990), may be the key connection to increase student learning in school, and even the overall life satisfaction of adolescents (Cikrikci & Odaci, 2016).

Statement of the Problem

While metacognition has been found to be an important component of academic performance and can be explicitly taught to teachers and students, it is often an unseen ability (i.e., not readily noticed

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by observers) (National Research Council, 2000), and it is common for teachers to be unfamiliar with metacognitive processes (Hughes, 2017; McKendree & Washburn, 2017; Seraphin et al., 2012). With little formal training in, and low competence in metacognition among teachers, more research is needed to further examine how educators perceive metacognition in themselves and their students. This study is part of a larger research project in which the researchers explored how educators facilitated learning and perceived metacognition in a project-based learning (PBL) instructional environment after participating in professional development on metacognitive strategies.

Metacognition and Learning

Metacognition has been defined as "individuals' ability to understand and manipulate their own cognitive processes" (Reeve & Brown, 1985, p. 343). Research over the past forty years has found metacognition to be relevant and important in the learning process for students. In a meta-review of 179 books and papers, metacognition was found to be among the most important variables for student learning (Wang et al., 1990). Using a codebook of 228 items sorted into 30 scales of learning variables, the item most important to student learning outcome achievement was metacognition, followed by effective classroom management and quantity of instruction. A study in agricultural education further supports the claims of metacognition's impact on the learning success of Career and Technical Education (CTE) students. An exploration of agricultural education students' performance on an electrical circuit test with and without a self-questioning protocol found students who used the self-question protocol (a metacognitive strategy) scored 10% higher than students who did not use the protocol (Pate & Miller, 2011). These findings underscore the importance of metacognition in the learning process, but also suggest even incremental enhancements of metacognitive abilities (e.g., metacognitive self-questions) can affect student achievement.

More recent studies also highlight the impact of metacognition on the learning process. Exploring problem solving ability among high school agriscience students, Blackburn and Robinson (2016) reported students who generated a correct hypothesis were more efficient problem solvers than students who generated incorrect hypotheses "regardless of problem complexity" (p. 55). As a conclusion, authors suggested problem solving performance was attributable to information students "acquired and hypotheses they generated…support[ing] the importance of students employing metacognitive processes during" (p. 55) problem solving. The correlation between metacognition and students' ability to generate correct hypotheses further situates metacognition as a factor in learning that can potentially have a broad influence on student ability. McKim and McKendree (2020) support this notion, as they reported metacognition to be a significant predictor of systems thinking. These findings suggest metacognition be considered a crucial component of the learning process.

Teaching of Metacognition

In addition to a research base suggesting metacognition is important to student success in learning, metacognition is a skill that can be further developed by students with practice and explicit instruction. In a 2014 study, Thomas and Anderson investigated the learning environment of a chemistry classroom by employing an intervention that included the teacher shifting the focus of learning chemistry towards using a three-level framework (macroscopic, microscopic, and symbolic). They asserted the learning environment became more metacognitively-oriented and resulted "in metacognitive change in some students" (Thomas & Anderson, 2014, p. 153). Similarly, another study examined explicit instruction of metacognitive knowledge during 12 science lessons on reproduction and found explicit instruction was beneficial for both high achieving and low achieving students (Zohar & David, 2008). These studies would seem to support Lovett's (2013) postulation that metacognitive skills are best developed through practice with feedback from the teacher, within the context of the learning, and not in an abstract way. Stated differently, explicit instruction of metacognition is

important, as research has shown that "teaching, prompting, and facilitating learners' use of metacognitive skills results in improved learning performance" (Schwartz et al., 2013, p. 91).

Metacognition and Educators

While being beneficial to learning and a teachable skill, teaching metacognition presents a challenge for educators. The teaching of metacognition is complicated by metacognitive skills often being internal, and not readily available for others to perceive (National Research Council, 2000). While explicit instruction of metacognition is important because it can result in improved learning performance (Schwartz et al., 2013), there is sparse research on educators' comfort with metacognition as a concept, especially as a teachable skill. In a 2017 study, McKendree and Washburn examined agriscience teacher understanding and facilitation of self-regulated learning (SRL), which is a component of metacognition (Zimmerman, 2002). Researchers suggested agriscience teachers had an incomplete understanding of the cognitions involved with SRL; instead, focusing their understandings of SRL on student motivation and outward behavior. Studies in other areas have yielded similar findings. Despite Wilson and Bai (2010) describing teachers as having a rich understanding of metacognition, researchers suggested contradictions existed within those rich understandings. For example, contradictions like describing the need to teach metacognition explicitly (active process with guidance) on one hand, and then implicitly on the other (assigning tasks that require metacognitive thinking, but not providing the necessary guidance). The authors' reporting of these contradictory findings would seem to support an incomplete understanding of metacognition by teacher-participants.

Thus, there is a potential gap between broader academic and teacher educator understanding of metacognition, possibly contributing to the disparity in the perceived need (i.e., recognition of metacognition as key to the learning process based on research) for metacognition and the perceived understanding by inservice teachers. While metacognition is becoming more widely known – as evidenced by its inclusion in *How People Learn* by the National Research Council – it is a concept in which many teachers' perceived teaching behavior may not match their actual practice (Spruce & Bol, 2015). In a broad review of research on metacognition in science education, one of the four gaps in research was teachers' knowledge of, and professional development (PD) in, metacognition (Zohar & Barzilai, 2013). Given the importance of metacognition to both visible (e.g., academic achievement) and invisible (e.g., systems thinking) variables of student success, educators risk losing a sizeable amount of influence on their students' learning if they do not acquire a deeper understanding of metacognition and consider how they may facilitate it.

Research Questions

This paper will address the following research questions:

1. How do teachers facilitate student learning in a PBL instructional environment before and after metacognitive professional development?
2. What are educators' interpretations of student metacognitive regulation and knowledge during a PBL instructional environment?

Conceptual Framework

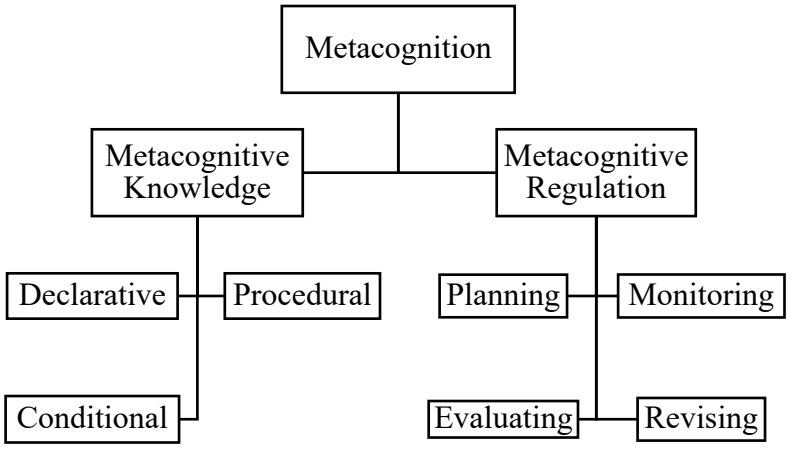
The framework for this study is tied to the underpinnings of two concepts in literature: (a) metacognition and (b) project-based learning.

Metacognition

Metacognition involves cognitions about cognitions (Flavell, 1979); or, thinking about one's thinking. Reeve and Brown (1985) defined it as "individuals' ability to understand and manipulate their own cognitive processes" (p. 343). Despite disparate conceptualizations of metacognition in educational psychology research over the past forty years (Young, 2010), researchers generally view metacognition as having two main components: a knowledge component and a regulation component (Brown et al., 1983; Jacobs & Paris, 1987; Schraw, 1998). Jacobs and Paris (1987) later suggested metacognitive knowledge consisted of three types of knowledge: declarative, procedural, and conditional. Metacognitive regulation was defined by Brown et al. (1983) as being regulatory activities such as planning, monitoring, evaluating, and revising. An and Cao (2014) postulated a model of metacognition. An adaptation of that model revised to fit the framework of Jacobs and Paris (1987) is shown in Figure 1:

Figure 1

Model of Metacognition (An & Cao, 2014) Adapted with Jacobs and Paris' (1987) Metacognitive Knowledge Elements



Project-Based Learning

Project-based learning (PBL) was chosen as the instructional backdrop to this study as it has been shown to be beneficial in motivating and increasing the thoughtfulness of students (Barron et al., 1998; Blumenfeld et al., 1991; Krajcik et al., 1998). Research has examined components of metacognition and differing forms of inquiry-based instruction, finding PBL (a) increases both students' motivation to learn and their interest in the subject matter (Gordon et al., 2001; Downing et al., 2009; Sungur & Tekkaya, 2006); (b) promotes elaboration strategies and self-reflection (Davis, 2003; Schraw et al. 2006); and (c) promotes self-directed learning (SDL) (Blumberg, 2000; Hmelo-Silver, 2004; Hmelo & Lin, 2000).

Project-based learning is a form of inquiry-based learning that focuses on students completing a collaborative project centered on a structured, authentic problem (Thomas, 2000). Specifically, PBL has five necessary elements: (a) engage students in solving an authentic problem, with the problem helping to structure the learning that will take place; (b) problems result in the creation of artifacts or products; (c) allows for investigation; (d) develops a community of inquiry (students, teachers, and community members); and (e) promotes cognitive tool use by students (Krajcik et al., 1994).

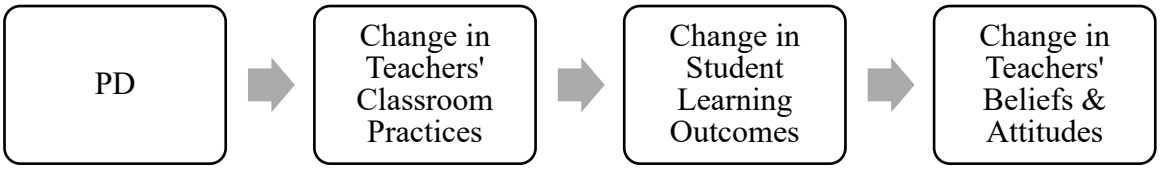
Theoretical Background

Model of Teacher Change

To frame our study, we draw on the Model of Teacher Change (MTC), first presented by Guskey (1986). Guskey's model proposes that for teacher change to happen, four elements are needed: (a) professional development; (b) change in classroom practice; (c) change in student learning outcomes; and (d) a change in teacher beliefs and attitudes. Guskey (2002) further elaborated on teacher change and growth, suggesting changes in attitudes and beliefs by teachers is focused more on student learning outcomes than on themselves as teachers. Guskey went on to contrast the traditional model of teacher change, where PD is aimed at altering teacher beliefs and attitudes in hopes of affecting their practice, and ultimately, student learning outcomes. In the revised model, Guskey stated teacher change starts with PD aimed at changing teacher practice, thus possibly resulting in changes in student learning outcomes, and, ultimately, changes in teacher belief and attitudes. A model of teacher change is presented in Figure 2:

Figure 2

Model of Teacher Change Adapted from Guskey (2002)



Within the MTC lies an important distinction: PD may encourage a change in teacher practice, such as a new instructional approach or new curricula, but a change in attitudes or beliefs by teachers does not occur until after the change in practice is supported by student learning evidence.

Using the MTC frame for teacher attitudes and beliefs, our study sought to gather teachers' experiences as they moved through the MTC with regards to metacognitive awareness and facilitation. Given the importance of metacognition to student learning and thinking, and the stated need for increased teacher understanding of metacognition, the lens of the current study could prove to be invaluable in broadening our understanding of how teachers process the acquisition of metacognitive understanding.

Methods

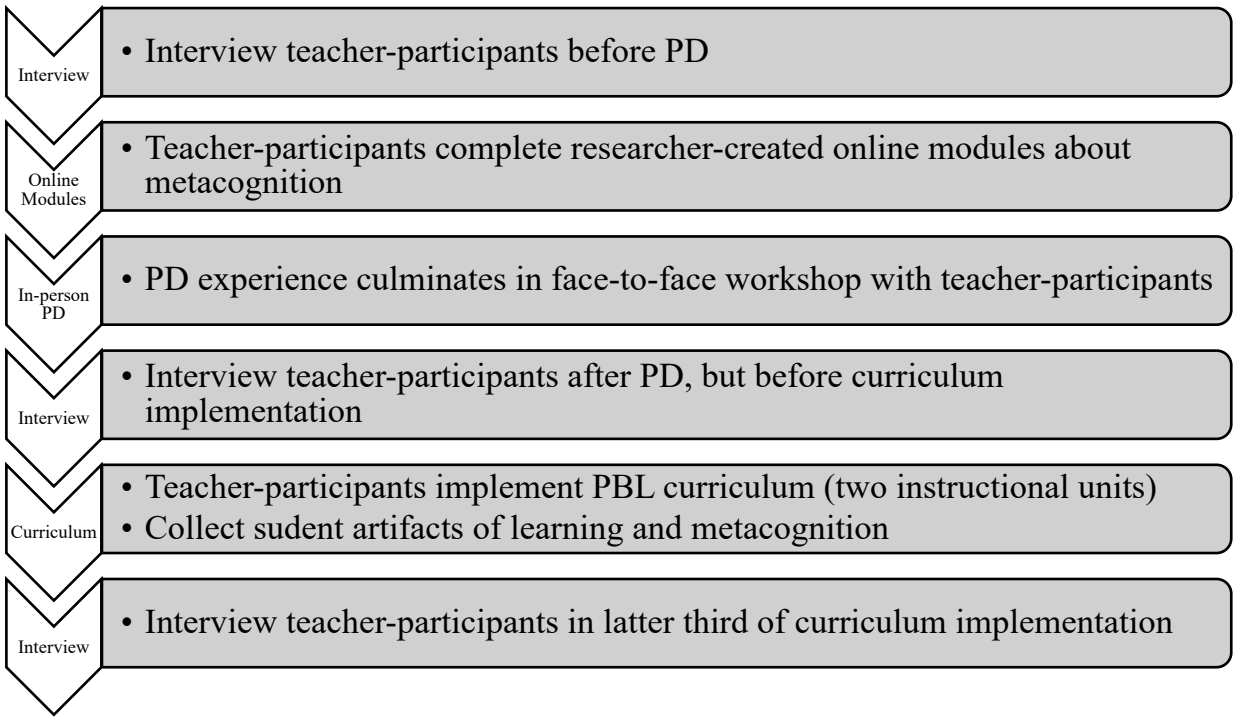
Overview

Data collection was in-depth and followed an interpretivist approach, allowing the researcher to understand participants' meaning making "as mediated through the researcher as instrument" (Merriam, 2002, p. 6). Following Flick's (2009) suggestion, a series of three semi-structured interviews were employed as interviewees' viewpoints are "more likely to be expressed" (p. 150) during a semi-structured interview. The lead researcher facilitated a metacognitive PD, and the research team then asked teacher-participants to implement two, four-week units of PBL curriculum into one class of their choosing. Participants were selected from a pool of 85 secondary teachers from Kansas, Nebraska, and Florida who had previously undergone training on a food science focused PBL curriculum and were

already implementing the PBL curriculum within their courses. Six participants completed the study (see Findings for a rich description of each participant). Prior to interviews and PD, participants provided informed consent to the researcher in accordance with Kansas State University's IRB protocols. Figure 3 outlines the research design of the study.

Figure 3

Research Design



Metacognitive Professional Development and Curriculum

The lead researcher created a PD program on metacognition to increase teacher-participants' awareness of and ability to facilitate metacognitive strategies. Two outside experts in metacognition then reviewed the PD, which was comprised of two elements, an online set of modules and an in-person training. The research team made the online element available to teacher-participants via the Kansas State University Canvas system after the first round of interviews. Each module (three total) included a researcher-narrated PowerPoint video lecture and optional discussion questions, and modules one and two included readings. The three modules were structured following the two components of metacognition posited by Brown et al. (1983) and Jacobs and Paris (1987): metacognitive knowledge (module 1) and metacognitive regulation (module 2). The third and final module focused on metacognition, both its relevance and how it affects student learning. Teacher-participants then had two weeks to complete the online modules before participating in a daylong in-person training.

The in-person PD concentrated on further helping teacher-participants make meaning of metacognition and challenged them to consider how they would attempt to facilitate metacognitive strategies with students. The lead researcher built the in-person training around Schraw's (1998) four ways to facilitate metacognition: (a) promoting awareness; (b) improving metacognitive knowledge; (c) improving metacognitive regulation; (d) and fostering conducive environments. Each of the respective four foci included a reading and discussion followed by practical application. As part of the

PD the lead researcher worked with teacher-participants to create curriculum-specific metacognitive interventions, including a regulatory checklist and strategy evaluation matrix (Schraw, 1998). After the PD, teacher-participants were encouraged to utilize the interventions within the PBL curriculum.

To ensure fidelity of curriculum implementation, we asked participants to record their PBL class using a Swivl device. We provided participants a Swivl during the in-person metacognitive PD and instructed them on how to operate it. The lead researcher scored each video selected for review following a researcher team-created rubric to determine fidelity of curriculum implementation. The fidelity rubric aligned with the principles of PBL posited by Krajcik et al. (1994).

Data Collection

To accomplish collection of data, the lead researcher conducted semi-structured interviews in a variation of the Seidman (2013) technique. As part of a larger study, interview protocols addressed: (a) teacher-participants' understanding and beliefs on the learning process before and after PD; (b) teacher-participants' feelings toward metacognition and students; (c) teacher-participants' perceptions of students' ability to utilize metacognition; (d) teacher-participants' perceptions of how they facilitated metacognition; and (e) teacher-participants' perceptions of the benefit of metacognition.

The first interview in the Seidman (2013) series involved putting the participant's experience into context. Next, the researcher focused on reconstructing the participant's experiences within the previously noted context in which those experiences occurred. Lastly, the third interview encouraged participants to reflect on the meanings of their experiences. We employed an adaptation of this model by having one interview before teacher-participants completed the metacognitive PD, one interview after the metacognitive PD, and the third interview after implementation of two units of PBL curriculum. The focus of this manuscript draws on data collected during all three interview rounds.

To increase credibility and confirmability, the research team completed member checks, utilized auditing, and peer debriefing after transcription (Flick, 2009; Guba, 1981). Member checks were completed by emailing the transcribed text to each participant, allowing them to review the data and determine if its contents were accurate and representative of their feelings. Member checks are a form of communicative validation, or trustworthiness (Flick, 2009). In addition to audit trails, peer debriefing was conducted with a second research team member periodically to review themes, categories, codes, and notes and to cross-check analyses, thus increasing the credibility of the research (Guba, 1981).

Triangulation

As a form of triangulation, the research team collected artifacts created by students during the PBL curriculum. The lead researcher created and embedded metacognitive prompts into the PBL curriculum, and then asked teacher-participants to have their respective students complete the writing prompt activities as they progressed through the curriculum units. Each of the two units from the PBL curriculum contained two writing prompts that required students to reflect on their learning during that unit of instruction, providing the researcher with insight into their metacognitive thinking. Each writing prompt contained four questions: two questions targeting metacognitive knowledge elements (i.e., one question on declarative knowledge and another on conditional and procedural knowledge), and two other questions geared toward metacognitive regulation (i.e., planning and monitoring, evaluating, and revising). The lead researcher then scored the writing responses with the aid of a rubric aligning with the conceptual framework of metacognition.

Reflexivity

I (lead researcher) examined and detailed how my interactions and prior experiences in education impacted my own meaning of the study. First and foremost, because of past experiences I have strong feelings about the impact School-Based Agricultural Education (SBAE) and other Career and Technical Education programs can have on learners. Emanating from those feelings towards SBAE, as a teacher I have a strong sense of responsibility to my students, and I assumed educators in this study shared similar beliefs concerning their diligence to students. Likewise, previous opportunities to work with the teachers participating in this study has also impacted how I view and respect them as educators. I have known the six teacher-participants involved with this study for several years and view each of them as proficient educators. These prior relationships had the potential to cause me to assume the best regarding teacher-participants' discussions of pedagogical decision-making.

Data Analysis

The lead researcher analyzed the data using the constant comparative method (Glaser, 1965). The constant comparative method is done through four stages: (a) comparing incidents to categories; (b) integrating categories and their properties; (c) delimiting the theory; and (d) writing the theory (Glaser, 1965). Although the constant comparative method of analysis connects with grounded theory research, it has become popular in other qualitative types of research (e.g., interpretivist approach) even though the research may not result in substantive theory development (Merriam, 2002). For this study, the lead researcher started analysis by comparing individual quotes with other individual quotes, until categories, and then eventually properties of categories began to emerge. Throughout the process, notes were taken on emerging themes and audit trails were periodically completed, with multiple research team members reviewing and reflecting on the emerging themes.

Findings

Findings for this study emanate from a larger research project that resulted in 167 pages of transcribed text and seven total themes. First, we present themes that emerged from the interviews for how participants progressed in their operationalization of metacognition. Next, we present findings on a per-participant basis, providing rich descriptions of how teacher-participants' views of metacognition changed over time, how they interpreted their students' metacognition, and what challenges they faced with facilitating metacognition.

Thematic Discoveries

We will focus on themes relevant to the two stated research questions for this paper: (a) Themes relevant to question one, which include *beliefs on teaching*, *PBL benefits*, and *facilitating metacognition*; and (b) Themes relevant to question two, which include *teachers' conceptualizations* and *teachers' partial conceptualizations.*

RQ 1 How do teachers facilitate student learning in a PBL instructional environment before and after metacognitive professional development?

After the metacognitive PD teachers valued metacognition enough to adjust how they facilitated learning, but those adjustments were somewhat thwarted by partial conceptualizations of the complex metacognitive process. Those adjustments included changing the types of questions they asked, how they worked with struggling students, and how they coached students. One example of how metacognitive PD influenced teacher-participants' beliefs on teaching was their reference to facilitating metacognition by increasing their expectations of students, as Mike said, "and then I would just put it

back on them to prove to me that it is or isn't [correct], which then forced them to revise if it wasn't." On several occasions, it was mentioned that an awareness of metacognition by the teacher would enable them to challenge student thinking and allow the teacher to expect more from the student. Some teacher-participants postulated challenging students to oversee their own learning would do this, directing and regulating their thinking on their own without the teacher doing it for them. For instance, Andrea suggested struggle (with regards to metacognition) is not something she would shy away from with her students, "frustration in my classroom is not a problem for me. I expect it, and I hope for it most of the time."

However, their conceptualization of metacognition was a limiting factor in how they attempted to facilitate metacognition. Oftentimes, teacher-participants failed to differentiate between elements of metacognition and PBL, citing metacognition as a way to enhance student accountability and topical relevance – the same ideas surfaced when teacher-participants discussed why they saw PBL as beneficial. Cindy offered an illustrative thought when she discussed how metacognition could work within PBL projects, "it is up to [them] how [they] want to study, use [their] time to study this information, or put this presentation together." This idea of metacognition being an avenue to hold students accountable is another example of an intertwining of PBL and metacognition in teacher-participants' minds, as they also suggested PBL would hold students accountable. This confusion may have contributed to teacher-participants somewhat viewing metacognition as an oversimplified strategy or teaching method, specifically when thinking of metacognition as an avenue to help them be better instructors or to aid their students in achieving higher order thinking about instructional content.

RQ 2 What are educators' interpretations of student metacognitive regulation and knowledge during a PBL instructional environment?

Teacher-participants' discourse conveyed dichotomous messages: At times they hinted at a sound understanding of metacognition and described student use in accurate detail (i.e., *teachers' conceptualizations*); however, those accurate descriptions were interspersed with partial understandings that confounded metacognition with effective or improved instruction (i.e., *teachers' partial conceptualizations*) or cognitive understanding.

Teacher-participants did have accurate conceptualizations of parts of metacognition. One of these was a clear understanding of metacognitive declarative knowledge, or the knowledge one has of themselves as a learner. Mike postulated an emblematic statement when he discussed a student who is successful at metacognitive knowledge as one that is quicker to achieve mastery because of their "previous experience on how they know they learn best." Conversely, Cindy discussed identifying a student struggling with metacognitive knowledge as "they have the far outcome that they are supposed to be reaching, but they don't know which path to take to get there." Frequently, teacher-participants cited the need for metacognitive declarative knowledge in the learning process, even describing how they would identify a student who struggles with it. Somewhat less frequent were discussions of ways to help students increase said knowledge. Teacher-participants at times focused on avenues for attaining declarative knowledge about their learners for themselves, as Mike said it "would help me understand how they would learn best," not fully recognizing the benefit of having a student take a learning inventory so the student can then understand more about their own ways of thinking. Tim suggested something similar by describing where metacognition fits into the learning process, "Not only is it something that we need to think about as a way of getting kids to learn, but I think it also allows us to think about how to prepare [lessons]."

Teacher-participants' entangled thoughts of PBL and metacognition may have contributed to a somewhat common view of metacognition as cognitive understanding and elements of behaviors of a 'good student' (i.e., engaged in the activity and making connections with the content from day to day).

This was evidenced when Tim described metacognitive struggle as a "student not as structured or as hard working I guess I would say or engaged as we'd like to see." Continuing, teacher-participants commonly focused on students who made connections with content and were able to understand things quickly as being metacognitively advanced. Gabby offered an emblematic thought about students who don't possess metacognitive knowledge, "there was no connection whatsoever. So for them every day was an individual lesson. And the kids I could tell that were using it were like, oh, this is how what we did yesterday relates to this today." While elements of these ideas may prove in alignment with metacognition literature, their experiences potentially underscore an imperfect understanding of all the metacognitive components. Specifically, in reference to 'good student' beliefs, engagement highlights the outward appearance of a student, representing the doing, but ignores the mental processes the student is conducting. A student may be a willing participant but may or may not enact metacognitive regulation based on metacognitive knowledge they may or may not possess.

Individual Participant Implementation and Interpretation of Metacognition

Andrea

Andrea is an early mid-career teacher, who is respected and knowledgeable at her craft. Arguably, she made the most connections conceptually with metacognition, expressing confidence after undergoing the professional development. Her confidence manifested in a high self-perceived use of metacognitive strategies after completing the PD events. Additionally, she had a plan for implementing metacognition in her class, "I think throughout the lesson, just being more vocal in how I use my thinking process to help them start to see where that works." Further supporting overall comfort with metacognition and the study, she had the second-highest curriculum fidelity score among the six teacher-participants.

While her confidence remained, she described her students' confidence with metacognitive strategies as being more fickle, "as far as my students, I don't know, they were sophomores, so I, there's a part of it that I think they're still growing and still developing." Scores for the metacognitive student writing artifacts would support the mixed review of her students' metacognitive confidence, as the mean score for metacognitive knowledge decreased over the course of the study, while the mean score for metacognitive regulation increased. She also frequently made the connection of metacognition with coaching, describing needing to demonstrate her thinking for students and then coach them through struggles when they encountered them:

> I think you can go back and, if students are saying 'I'm just not getting it, I'm just not understanding,' you can have them show you their work and you can do a more effective job of coaching them of 'well this is possibly why you're not understanding it.'

However, like another teacher-participant (Tim) she made connections between metacognition and reflecting, in that she felt students were more metacognitive at the end of a unit when they can see how everything connects,

> the presentation stage…in this curriculum…there's a bunch of experiments that are going on, and for some reason my students …just look at that as a daily assignment….And then when they're doing their projects they connect those as if it is, you know, a full week of a project, so that is connected together.

Additionally, she found value in metacognition because it helped her see student learning differently, "being able to look at students in a different lens and in a different light of it's not that they can't organize their information, they just might not know how to yet." She postulated it also helped her think about students differently, "it helps you individualize your students and teach to individuals rather than just teach the content." A note not to be dismissed, she commented the projects her students submitted were better than in previous years of teaching this curriculum.

Cindy

Like Andrea, Cindy is an accomplished, respected educator who is entering the early phases of being 'mid-career,' and at times this may have impacted her feelings towards teaching and learning and her students. Cindy has been teaching long enough to have confidence in her abilities but is pliable enough to adapt her paradigm of teaching and learning based on new ideas she learns during PD events. This was evidenced when she described how students go about learning, "they know they need to learn, but they don't put a lot of thought – some of them don't put a lot of thought into what that might look like." She was also willing to think critically about what metacognition might look like, as she postulated metacognition is "something that impacts the way your students learn on … a whole other level that you may or may not have been aware of when you went through the teaching block at whatever school you went to."

While she was engaged and willing to try metacognition facilitation, there were two potential inhibitors to fully conceptualizing, and operationalizing, metacognition: familiarity with PBL and perceptions of student commitment. First, albeit a positive in other ways, Cindy was very familiar with the PBL curriculum. She completed multiple PBL workshops focused on the curriculum used in this study and was a lead teacher for one of the trainings. Her curriculum fidelity score – the highest in the study – provides further evidence of this. She values PBL and its benefits, as she discussed it, "[PBL] holds them accountable for their learning more." Additionally, because of her affinity for PBL, and her familiarity with the curricular units, she may have confounded elements of metacognition with those of PBL, as she highlighted metacognition contributes more "ownership" of learning by students during PBL. Secondly, her discussions seemed to indicate she was in a phase of her career where she questioned students' commitment to education. Commonly, she referenced students having an ability to do more than they were willing, as she described a student struggling with metacognitive regulation as one that would "just go up and wing it [presentation]." This feeling toward student (lack of) commitment may have confounded her conceptualization of metacognition as the study progressed; focusing more on the effort aspects rather than the ability students may or may not have to think metacognitively.

Cindy's participation in the metacognitive PD events, as well as her second interview, indicated she was conceptualizing metacognition well early on. In her interview after the metacognitive PD, she described an understanding of metacognition when talking about how students need to adjust their own learning,

> I think it's extremely important for students to understand…how they learn, and making those choices to learn in the way that works for them is really important. Instead of just focusing on learning. Like, they know they need to learn, but they don't put a lot of thought – some of them don't put a lot of thought into what that might look like. And then choosing different options for the appropriate time is really [important]….choosing different options that actually do work.

However, other data sources like the student writing prompts from the first curriculum unit were incomplete and unavailable to provide further insight – potentially alluding to a dwindling efficacy towards metacognition as a concept. Mirroring the trend toward a confounding conceptualization of metacognition, scoring of her student's metacognitive writing prompts decreased over the period of the second PBL unit.

Gabby

Gabby never quite seemed comfortable enough with metacognition to go "all-in." This is despite her being a well-respected teacher with good experience in PBL. Gabby seemed to leave the PD with a firm grasp on metacognition, as she was thoughtful as to how she could implement

metacognitive strategies during the second interview. She described her feelings as needing to be intentional in helping students recognize the skills they need to be successful in learning, "get students to recognize that the skills that they need to be successful in the learning process, as a teacher [I] have to be much more intentional in what [I'm] doing and saying to help them through that process." Additionally, she left the PD with a positive (or strong) self-perceived use of metacognitive strategies.

Her enthusiasm however devolved as she moved forward with the curriculum, as she said "it was harder than I thought it would be with them." Towards the end she felt less confident, and at times was confounding metacognition with self-regulation – focusing on metacognitive knowledge happening at the beginning of a unit and metacognitive regulation happening at the end of the PBL unit. She said the beginning is an awareness phase, "so for me I see it as an awareness at the beginning," while the end is regulating, students are "regulating themselves to be able to use it and put it together for your classroom project that they're doing." An expert teacher, feelings of decreased confidence could have influenced her ability to go all-in. While she willingly participated in all three interviews, she was more hesitant regarding other elements, such as having students complete the curriculum writing prompts and recording her class sessions with the Swivl.

Mike

Always a deep thinker, Mike is quick to listen and ponders topics longer than most. He is a respected, experienced teacher and is a veteran at PBL, which had both beneficial and detrimental effects on his participation in this study. His propensity for deep thinking and his prior experience primed him well to be an excellent participant in the metacognitive PD and PBL curriculum implementation. However, his prior experience with PBL somewhat diverted his implementation of the curriculum – feeling he was not natural when implementing a "canned lesson." Similarly, at times he described a dearth of confidence when it came to metacognition and facilitating it with students. Students' scores on the metacognitive writings are emblematic of that wavering, as they slightly increased early on, but then decreased as the study advanced.

As the study progressed, Mike's confidence did not seem to rebound as related to metacognition, suggesting he needed to apologize "for not doing that better" as he struggled with sticking with the "script." Combine this with his feelings of the curriculum being "canned," and it resulted in him not being as willing to fully invest in the study – including implementing metacognitive strategies as well as recording class sessions with the Swivl – this is evidenced by his relatively low fidelity score for implementing the curriculum. Additionally, at times, he related metacognition to something that all students *can* do, they just might choose not to. For instance, he discussed metacognitive knowledge struggle, "I don't want to say laziness but just not willing to utilize the procedures that they already knew, you know they know what they are, they just choose not to use them." This is despite his eager and active participation in the metacognitive PD events, and his high self-perceived use of metacognitive strategies.

Nina

Qualified and thinker are adjectives that accurately describe Nina and her teaching style. However, she seemed hesitant to apply metacognition throughout the study, feasibly because she was unable to find a place conceptually where she felt comfortable with it. This is despite her initially displaying enthusiasm consistent with her persona as an educator: willing to try new things and learn challenging ideas, as she described the value of metacognition, "if we all just stopped and [had] a little bit more understanding and training…we would see a big difference in our classrooms." Both her

participation in the metacognitive PD elements and her self-perceived use of metacognitive strategies indicate she began the study with a solid conceptualization of metacognition.

However, as she progressed into the first few days of curriculum implementation, her reservations became more apparent. After the PD, her focus was on hesitantly trying out metacognitive facilitation, "I learned a lot, but I walked away thinking I really need to learn more." This potentially indicates self-efficacy concerns arose when attempting to operationalize metacognitive facilitation. Not long after starting the PBL curricular units, she decided to discontinue the implementation, citing difficult school conditions as the main motivator for the decision (i.e., multiple students enrolled in the course withdrawing from school).

While her reservations in her ability to be comfortable and smooth with metacognition may have influenced her decision not to finish curriculum implementation, she did complete the third-round interview. In that third interview, she described still finding value in metacognition but needing more reinforcement and refinement of it to attain a higher comfort level.

Tim

A veteran, respected teacher, Tim was a unique participant in the study in that he is masterful when it comes to content knowledge. Likely, he was teaching with a Project-based instructional design years before this study. As he progressed through the PD and curriculum implementation, Tim expressed confidence in metacognition and PBL, as he characterized his feelings about metacognition with a hint of dismissal, "metacognition is fine." However, he frequently related metacognition to elements of cognitive learning, like a student's ability to relate newly learned information to other topics, "and gives that opportunity for kids to have the realistic-ness and the building upon situation, and to use it to where they're going to have the opportunity to just keep learning and falling back on things." Relatedly, after curriculum implementation he suggested students tend to be most metacognitive at the end of a unit, when they are putting knowledge together "because we're starting to put [previous learning] together." Finally, he often expressed the idea that metacognition was an avenue for developing deeper thinking or learning that would be for the "long-term." Tim's mixed perceptions of metacognition was further evidenced by the scores on his students' writing artifacts, as they varied as the study progressed.

Another factor in Tim's participation was his extensive experience with PBL, and the main topic of the PBL units in this study (i.e., food science). Often, he would start and stop the curriculum to implement his own topics and activities, limiting the fidelity in which the curriculum and metacognitive strategies were utilized. His fidelity score evidenced this, as it was the lowest of all the teacher-participants.

Conclusions and Implications

We present conclusions based on two ideas: (1) even though teacher-participants were metacognitively aware following the PD, they struggled with operationalizing and facilitating it; and (2) based on these teacher-participants' experiences, more PD may be needed for complex topics like metacognition.

Metacognitively Aware, but Facilitation Troubles

As teacher-participants left the metacognitive PD event, they described an understanding of metacognition and of being metacognitively aware. They could define elements of metacognition and provide examples of what metacognitive knowledge and/or regulation struggle and success looked like

with their students. Put simply, they knew what metacognition was and how they utilized it for themselves. However, despite that metacognitive awareness, as the study progressed, they began to struggle with operationalizing and facilitating metacognitive activities with their students.

When attempting to operationalize metacognition with their students and facilitate it, they would frequently begin focusing on metacognition as a higher-order learning activity, confuse it with making outside connections to current learning, or just feel overwhelmed. In essence, they knew metacognition well enough to describe it, but not well enough to facilitate it. At times, teacher-participants admitted their feelings of facilitation struggles, as Nina openly suggested she still needed to learn more following the PD event. Teacher-participants struggled with taking a concept (metacognition) they could define and facilitating it with their students. This is not unlike other topics educators teach, where one may understand a topic for his/her own benefit, but not grasp it fully enough to teach it to others.

One substantial research recommendation highlighted by this revelation is incorporating a third-party observation to gauge teacher application of metacognitive strategies. This would also allow for observation of metacognitive thinking by students. Further, data collected could inform follow-up PD, basing the PD structure on elements of metacognitive facilitation teachers are struggling with and reinforcing elements done successfully.

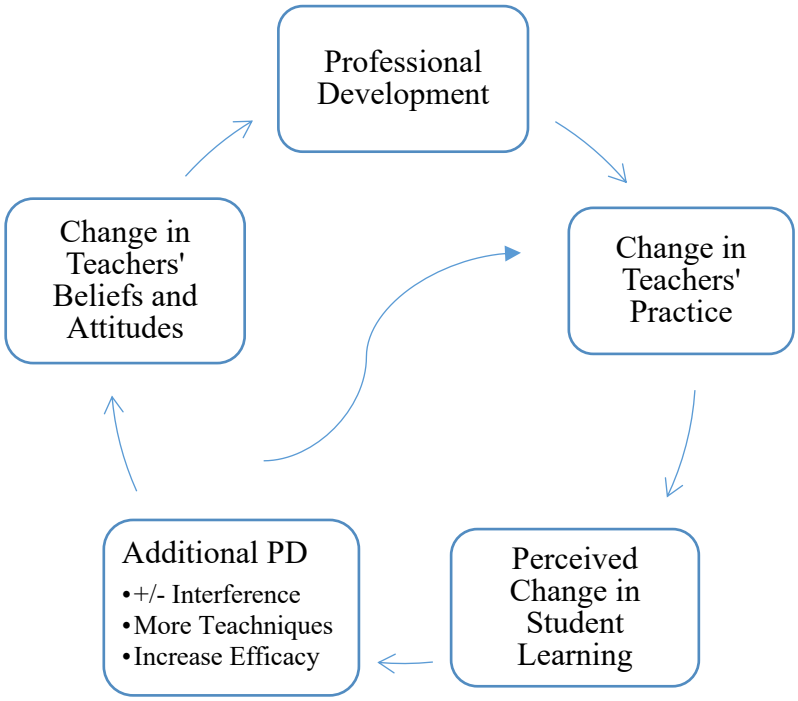
Additional PD for Complex Topics

The disconnect between an awareness of metacognition, and an ability to facilitate it with students, leads us to the second conclusion. When learning about an idea that challenges existing paradigms on learning and teaching, more PD may be needed as teachers progress through the stages of the Guskey (2002) Model of Teacher Change. Specifically, additional PD taking place after teachers have experimented with implementing new knowledge from the initial PD experience, but before they can solidify new beliefs, could be warranted. While the metacognitive PD succeeded in increasing teacher-participant awareness and interest in metacognition, they struggled with how metacognition fit within their existing paradigms and how they were going to facilitate it. New questions arose after metacognitive interventions were tried for the first time, and in the absence of information, teacher-participants filled gaps in conceptual understanding with what they already knew about learning and teaching (e.g., higher-order thinking).

Research exists that advocates for longer PD experiences, as five critical features of effective PD have been identified: 1) content focus, 2) active learning, 3) coherence, 4) duration, and 5) collective participation (Desimone, 2011; Garet et al., 2001). Specifically, authors operationalized duration to have two elements, contact hours (i.e., amount of time spent focusing on a topic) and span (i.e., period of time that the activity took place) (Garet et al., 2001). It was postulated PD extending over time allows for teachers "to try out new practices in the classroom and obtain feedback" (p. 922). Based on these ideas, we propose an adapted model for teacher change and complex topics (see Figure 4):

Figure 4

Model for Professional Development in Complex Topics, Adapted from Guskey (2002)



In the original Guskey (2002) model, teachers would undergo a PD event, enact new practices learned during the PD, gauge student outcomes of new practices, and then ultimately decide whether to adjust their attitudes and beliefs. While teacher-participants' discourses affirm Guskey's model and its description of how teachers progress through change, the model does not account for additional PD events that may be needed for complex topics, and the intentionality of when those additional events take place. In the revised model, additional PD opportunities are included based on teacher-participants' experiences with metacognition and Desimone (2011) and Garet et al.'s (2001) postulation that longer period PDs are important for teachers to have implementation and feedback opportunities. An important distinction from previous work is the additional PD is expanded to focus on potential interference with teacher conceptualization and operationalization of the topic (e.g., metacognition). After teacher-participants underwent metacognitive PD they understood what metacognition was, and some avenues for facilitating it with their students. However, as they attempted to facilitate it, they were faced with challenges to their understanding, which ultimately resulted in negative interference (i.e., associating metacognition with other items that are similar, but not actually metacognition). As a result, when teacher-participants were assessing student outcomes and making changes to their beliefs and attitudes about teaching, they were doing so with partial conceptualizations of metacognition. The adjustment of the model is not simply an admission for the need of additional PD, instead it is a focus on the need for intentionality of when additional PD may be valuable to confront interference of teacher learning and beliefs and attitudes.

An adapted PD model accounting for the intricacies of a complex topic like metacognition would incorporate opportunities for application of metacognitive facilitation strategies. A revised PD model would include a longer span, allowing for PD events to occur after teachers have applied their new strategies and learning. The revised PD model would be a more iterative process that would allow

teachers to gain new knowledge, practice applying it, see student outcomes, and have possible belief changes, all in a circular process that provides multiple learning opportunities. The revised model could provide teachers with an opportunity to practice new ideas on teaching, but also offer the opportunity to revise and refine their understanding of the PD topic given its complexity. The additional PD offerings included in the lengthened span could focus on several potential areas: (a) further analysis and application of metacognition facilitation strategies, including practice facilitating metacognitive-enhancing activities; (b) refined conceptualization of metacognition, focusing on reducing the impact negative interference has on teacher understanding, such as projecting PBL properties onto metacognition (e.g., an avenue to engage students); and (c) further consideration of how metacognition may impact how learner success is viewed.

Implications for practice include teacher PD and metacognitive facilitation avenues with students. Related to metacognitive PD, an implication involves parsing PD out into three foci happening in multiple occurrences: (a) increasing awareness by focusing on what metacognition is; (b) exploring avenues for facilitating student metacognitive use; and (c) refining metacognitive understanding and facilitation after initial implementation. Incorporating the revised model with this three-part process may enable better metacognitive professional development for teachers. Additionally, potential facilitation attempts with students can focus on strengthening metacognitive knowledge and regulation, regardless of instructional setting (e.g., regulatory checklists and strategy evaluation matrices). Further, increasing the focus on metacognition in teacher education programs can help the profession better facilitate metacognition.

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