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Teachers' epistemic cognition in situ: Evidence from classroom assessment☆

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ABSTRACT

Assessment tasks require the coordination of multiple knowledge-related goals for various audiences, and therefore provide an authentic context to observe teachers' epistemic cognition in practice. In this instrumental case study, we investigated seven, fifth grade English Language Arts teachers' epistemic cognition as they evaluated students' classroom assessments. Our analyses revealed that the components of epistemic cognition identified in the literature emerged in these teachers' assessment processes. Moreover, we found evidence that teachers' epistemic cognition was iterative and nuanced, and required shifts in aims and reliable processes. This resulted in teachers forming new kinds of "epistemic matters" and questions beyond those ideas noted in existing models of epistemic cognition. Significance and implications are discussed.

1. Introduction

Teachers engage in a number of complex tasks as part of their daily work, including establishing goals and enacting practices related to planning lessons, implementing instruction, and assessing student learning. When these tasks require teachers to consider knowledge or understanding, they are epistemic in nature (Fives, Barnes, Buehl, Mascadri, & Ziegler, 2017). Greene and Yu (2016), building on the work of Chinn, Buckland, and Samarapungavan (2011) and Hofer and Bendixen (2012), defined *epistemic cognition* as the "ability to construct, evaluate, and use knowledge" by drawing on one's "dispositions, beliefs, and skills [to] determine what [is] actually known versus what one believes, doubts, or distrusts" (p. 46). In other words, it refers to what individuals do when they deliberate about knowledge and truth (Greene & Yu, 2016). When engaged in epistemic cognition, individuals consider the standards, parameters, and certainty of their knowledge (Maggioni & Parkinson, 2008).

Teachers are in a unique position because not only must they engage in epistemic cognition to determine what they themselves know, they must also use epistemic cognition to assess the knowledge of their learners (Buehl & Fives, 2016; Fives et al., 2017). To help learners construct knowledge, teachers need to understand and examine the dimensions of that knowledge in each aspect of their teaching practice, including assessment. Assessment is the "process of obtaining information that is used to make educational decisions about students, to give feedback to students about their progress, strengths, and weaknesses, to judge instructional effectiveness and curricular adequacy, and to inform policy" (Federation, 1990, p. 1). In other words, assessment is a *process* that teachers use to inform their teaching and improve student learning (e.g., formative: Black & Wiliam, 2009), determine performance (e.g., summative/grading: Brookhart et al., 2016), or identify students' strengths and areas of improvement (e.g., diagnostic: Brookhart & Nitko, 2019). We target *classroom assessment,* which focuses on assessment processes that teachers enact in their classrooms (Pellegrino, 2012).

Classroom assessment, in particular, requires teachers to consider the nature of knowledge and determine the quality of their students' knowledge, and therefore potentially provides a rich context to observe their epistemic cognition. During classroom assessment, teachers select or construct *assignments* to gather evidence about students' knowledge or skills that can be used to inform their knowledge and decision making. *Student work* refers to specific documented products completed in response to a given assignment. This work can be documented by the student when he/she responds to an assignment or by the teacher who observes a student perform an activity and records that observation.

In this instrumental case study, we sought to uncover and understand the phenomenon of teachers' epistemic cognition within the context of classroom assessment and to provide examples of teachers enacting epistemic processes. To do so, we examined seven teachers' reflective self-talk as they interpreted student work of English Language

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Arts (ELA) assignments or explained their classroom assessment practices. We were interested in determining if, and how teachers' epistemic processes compared to theoretical models (e.g., Fives et al., 2017; Chinn et al., 2011) and to offer illustrations of how teachers engaged in epistemic cognition in situ. Building on research from scholars in learning sciences and educational psychology that have examined learners' epistemic cognition, we explored teachers' epistemic cognition during their professional practice in order to, as Buehl and Fives (2016) suggested "identify places where epistemic cognition is a hidden practice" (p. 280–281). By offering varied and numerous exemplars of teachers' epistemic practices, as called for by Alexander (2017), we aim to extend theory and research on epistemic cognition to include examples of such potentially hidden practices as they might occur during classroom assessment.

2. Epistemic cognition

What is knowledge? How do we know what we know? These are core questions of epistemology, the study of knowledge and knowing. Educational researchers argue that the responses to these questions reflect a set of beliefs, epistemic beliefs, that influence how individuals engage in learning tasks (see Hofer, 2016 for a review). Researchers are also interested in the closely aligned process of *how* we come to know, that is, epistemic cognition (e.g., Chinn, Rinehart, & Buckland, 2014). Epistemic beliefs and epistemic cognition have been examined across content domains (e.g., math, science) and groups of individuals (e.g., students, teachers).

Researchers using developmental (King & Kitchener, 1994; Perry, 1970) and multi-dimensional (Hofer & Pintrich, 1997; Muis, Bendixen, & Haerle, 2006; Schommer, Crouse, & Rhodes, 1992) models of epistemic beliefs provided descriptive understandings of these beliefs and the potential influence of these beliefs on relevant academic outcomes such as learning and motivation (Muis & Franco, 2009). However, the process by which individuals ascertain beliefs about knowledge or come to see particular claims as knowledge (i.e., epistemic cognition) has received less attention. New understandings in this field have focused on this process orientation. In this investigation we utilized the theoretical framing of Chinn et al.'s (2014) AIR (i.e., aims, ideas, reliable processes) Model of epistemic cognition situated in the work of teachers as theorized by Buehl and Fives (2016).

2.1. Epistemic cognition: the AIR model

Chinn et al. (2014) proposed a multidimensional model of *epistemic cognition* that focused on the cognitive processes engaged when considering matters related to knowledge. This model included three central components: epistemic aims and values, epistemic ideals, and epistemic reliable processes (i.e., the AIR model), each of which were conceptualized as situated in task, domain, and context. Individuals establish epistemic aims when they set goals related to seeking knowledge, understanding, explanation, justification, or wisdom. They indicate value by the importance they attach to these goals. Reliable processes are invoked to achieve aims and may include strategies, skills, or other cognitive actions. To determine whether the epistemic end is achieved, individuals weigh progress toward and achievement of their epistemic aims using epistemic ideals, which are their beliefs about the nature of knowledge (structure, certainty) and knowing (source, justification; Bråten, Britt, Strømsø, & Rouet, 2011).

In the field of epistemic beliefs and cognition, researchers and philosophers have typically investigated the epistemic processes of learners (e.g., Chinn et al., 2011; Greene, Azevedo, & Torney-Purta, 2008; Greene & Yu, 2014; Hofer & Pintrich, 1997, 2002; Kitchener, 2002; Muis, 2007, Muis, 2008; Muis & Franco, 2009; Sandoval & Cam, 2010). For example, Barzilai (2017) examined how young adolescents engaged in an educational simulation game, established epistemic aims, enacted epistemic reliable processes, and engaged epistemic ideals. Examples of epistemic aims included actions or verbalizations that related to achieving an assumption, explanation, understanding, or an evaluation in the game, such as knowing how to play the game or understanding why an action occurred. To justify or evaluate these products, game players employed a series of epistemic ideals, such as "knowledge is complex" and "knowledge enables success in the game" (Barzilai, 2017, p. 58). Epistemic reliable processes were the cognitive actions, game players initiated to learn the game. Examples of epistemic reliable processes included using different sources of knowledge such as observation, testimony, and memory; cycles of inference and verification; and comparing/contrasting the game to the real world. In this manuscript, we contribute to and extend the work in this field by considering the epistemic cognition processes enacted when teachers consider knowledge-related issues as they engage in classroom assessment.

2.2. Teachers' epistemic cognition

Teachers' epistemic cognition refers to teachers' active contemplation of knowledge claims, processes of knowing, and the construction of knowledge (Buehl & Fives, 2016; Hofer & Bendixen, 2012). This active process is informed by teachers' self-systems which include their prior knowledge, existing epistemic beliefs (ideals), and epistemic vices and virtues (Fives et al., 2017). Prior research has explored teachers' epistemic beliefs or personal epistemologies as variables that influence important aspects of teachers' work such as their lesson planning, content selection, and instructional strategy use (Sosu & Gray, 2012; Yerrick, Parke, & Nugent, 1997). Recently Ferguson and Lunn Brownlee (2018) narrowed the focus of their study of epistemic beliefs to preservice teachers' beliefs about the certainty of knowledge in the field of teaching. They found that preservice teachers held a range of beliefs about how certain (unchanging) knowledge in teaching and learning is and such beliefs influenced how they approached learning contexts.

Buehl and Fives (2016) presented a framework of epistemic cognition in learning and teaching in which they argued that teachers engage in epistemic cognition twice: for themselves when they seek to learn (epistemic cognition for learning) and again for learners (students) when they evaluate or contemplate knowledge of and for others (epistemic cognition in teaching). Further, they situated epistemic cognition in a task and domain. Teaching tasks include activities related to planning, assessment, and instruction, and each is framed within a subject area or academic domain. This framework suggests that teachers may vary in their epistemic cognition as tasks and domains shift. Lacking from this framework however, was an explanation of *how* epistemic cognition might unfold in the real-life context of teachers' work.

Buehl and Fives (2016) hypothesized that tasks related to teaching, learning how to teach, or engaging in the practices associated with teaching require the consideration of multiple knowledge domains. For example, as a history teacher designs a unit on Civil Rights for her class, she must attend to the academic field of history and also the psychological field of child development in making selections about content and readings. Moreover, as she designs lessons she must consider the pedagogical knowledge that she could employ to help students construct knowledge about this topic as well as assessment practices that align with instructional choices to make sense of student learning. The multi-domain nature of teachers' epistemic cognition may be particularly evident in the context of classroom assessment, where knowledge of content, assessment, curriculum, and students may all come to bear on the processes of evaluating and constructing knowledge.

3. The assessment triangle

Pellegrino, Chudowsky, and Glaser (2001) developed the *Assessment Triangle* to illustrate three interrelated elements that underlie the process of assessment and that can be used to determine the quality of a

single assignment used to gather evidence of student learning. The three elements of the assessment triangle are: cognition, observation, and interpretation. The cognition vertex of the triangle encompasses a theory of learning and assumptions about knowledge representation in a subject matter domain, which are used to "identify the set of knowledge and skills that are important to measure for the intended context" (Pellegrino, 2014, p. 69). The observation vertex refers to assumptions and principles about the nature of tasks that will evoke accurate and informative demonstrations of knowledge from students. Lastly, the interpretation vertex "encompasses all the methods and tools used to reason from fallible observations" (Pellegrino, 2014, p. 69). In order for the assessment process to lead to sound decisions about learners each element must, in and of itself, be coherent and reflective of current research in the field, as well as be in sync or alignment with the other two elements (Pellegrino, 2014; Pellegrino & Wilson, 2015). Thus, the assessment triangle model provides a framework for considering both the individual elements as well as how they work in tandem or tension with each other.

Tomanek, Talanquer, and Novodvorsky (2008) used the assessment triangle model to explore 51 preservice and 41 experienced science teachers' written evaluations of possible formative assignments. In this qualitative study, these researchers focused on the observation vertex of the assessment triangle by asking participants to consider the quality of potential assignments and to reason through their decision making process about whether the tool would be useful for the purpose of formative assessment. Their analyses revealed that participants used two sets of factors to make decisions about the potential of the assignments: (1) characteristics of the task factors and (2) characteristics of the student or curriculum factors. Task factors included expectations about the level (i.e., high/low) of student thinking required by the task, evidence of student understanding that would emerge in their completion of the task, the appropriateness of the thinking level, the focus on the target concept, and the extent to which the task allowed for student creativity and demonstration of knowledge transfer. In contrast, factors associated with the student or curriculum described the extent to which the task raised concerns and possibilities: concerns about students' writing/reading abilities and amount of prior knowledge needed to complete the task; and possibilities for connections to other curriculum activities. Thus, while putting the spotlight on observation, these researchers were able to unearth factors participants used to justify their decisions about the possible use of the assignments.

The work of Tomanek et al. (2008) also lends support to Fives et al.'s (2017) theoretical contention that within each element of the assessment triangle teachers consider epistemic matters at both an individual level, evaluating students' knowledge representations, as well as at a socially-constructed level in which knowledge of content/subject matter, child development, and pedagogy are considered to make informed decisions about what to assess and how to assess it. For instance, Tomanek et al. (2008) identified that participants considered issues related to the specific capabilities of students (e.g., prior knowledge, language ability) in completing the potential assignments along with issues related to socially agreed upon conceptualizations of knowledge (e.g., building toward other curriculum activities) in their concerns about the content targeted in each potential assignment. Therefore, there seems to be some potential for utilizing one element of the assessment triangle as a focus for explorations of teachers' assessment practices.

4. Teachers' epistemic cognition in classroom assessment

When teachers engage in classroom assessment they need to consider students' knowledge representations (i.e., epistemic matters) in relation to a series of standards and expectations (i.e., epistemic ideals) in order to make a judgement regarding what students know and are able to do (i.e., epistemic aims/ends). Pellegrino and Wilson (2015) argued for the conceptualization of assessment as *evidentiary reasoning* which we equate with epistemic cognition. According to Pellegrino and Wilson (2015) teachers engage in evidentiary reasoning when they "draw reasonable inferences about what students know" (p. 264). Thus, when teachers' classroom assessment practice is focused on the interpretation vertex of the assessment triangle, wherein they make inferences about student knowledge, epistemic cognition should be enacted.

Fives et al. (2017) provided a theoretical argument that teachers engage in epistemic cognition during classroom assessment tasks. That is, teachers consider issues of knowledge as they engage the elements of the assessment triangle model. Building from this argument and in line with Chinn et al. (2014), in this investigation we recognize the three interactive components of epistemic cognition (i.e., aims, ideals, and reliable processes) as essential to the engagement of epistemic cognition within and across the elements of the assessment triangle, which are also interactive and dynamic.

Epistemic aims for teaching can include knowledge focused learning goals for the teacher or for learners (Buehl & Fives, 2016). As hypothesized by Fives et al. (2017) teachers establish epistemic aims for themselves when they identify epistemic matters that they want to know or understand. For example, when interpreting student work teachers set epistemic aims related to their understanding of students' knowledge representations (i.e., student work). Teachers also establish epistemic aims for their students when they identify knowledge focused learning objectives.

Following Chinn et al.'s (2014) conception of epistemic reliable processes we recognize these as the strategies or skills invoked to bring about epistemic ends. Within the interpretation element of the assessment triangle we expect that when teachers seek to understand student work, they use epistemic reliable processes to direct their own thinking. For instance, Fives et al. (2017) forwarded that teachers might employ a scoring rubric as an epistemic reliable process to determine what students know as part of interpreting their work and we argue that the same rubric may be offered to learners as an epistemic reliable process for them to interpret their own work (i.e., self-evaluation).

Epistemic ideals refer to teachers' existing beliefs about knowledge, related to the structure, justification, and source of knowledge. Structurally, individuals may believe knowledge to be certain/unchanging or uncertain/evolving that exists as a set of simple independent ideas or as a complex "integrated web of ideas" (Greene, 2009, p. 230). Beliefs about justification refer to the kinds of evidence needed for individuals to believe something to be knowledge; justifications may come from sources such as appeals to authority, personal reasoning, or direct observation (Chinn et al., 2014). We expect that such beliefs about knowledge are used by teachers when they engage in interpretation of student work. For example, if a teacher considers an idea from a novel to be complex and evolving then this becomes part of the epistemic ideal used during interpretation to determine whether or not students are developing accurate conceptions of the content.

The result of the interaction of epistemic aims, reliable processes, and ideals focused on an epistemic matter (i.e., epistemic cognition) is an epistemic end or product. For teachers, epistemic ends can be an end for themselves (i.e., stance, knowledge) or the practical application of the results of epistemic cognition to teaching: (i.e., epistemically informed praxis; Buehl & Fives, 2016). *Praxis* occurs when theory and practice are integrated and enacted by teachers. It is epistemically informed, when the actions teachers enact result from engaging in epistemic cognition. With respect to epistemic cognition occurring in the interpretation vertex of the assessment triangle an epistemic end for the teacher might be new understanding of his/her students (a stance) or a pedagogical decision (praxis).

5. Rationale for our study

Based on our review of the extant literature, we propose three ways in which this study adds to and extends the field of epistemic cognition.

These include (1) a focus on teachers as the unit of analysis and their epistemic practices, (2) a qualitative investigation into the processes of epistemic cognition, in particular, the use of think-aloud methodology as a way to externalize and capture teachers' epistemic cognition during the interpretation element of assessment, and (3) authentic examples of teachers' epistemic cognition during the interpretation element of the assessment triangle, unprompted and embedded in the complexities of teaching. We will elaborate on each of these in the next sections.

5.1. The need to examine teachers' practices

As stated previously, the vast majority of studies in epistemic cognition have focused on the learner (e.g., Chinn et al., 2011; Greene et al., 2008; Greene & Yu, 2014; Hofer & Pintrich, 1997, 2002; Kitchener, 2002; Muis, 2007; Muis, 2008; Muis & Franco, 2009; Sandoval & Cam, 2010). The findings from these studies and others have contributed in important ways to understanding how students reason about knowledge or come to understand content in a discipline. As orchestrators of classrooms, teachers inevitably become facilitators of students' knowledge construction. Shifting the focus of epistemic research to teachers allows us to understand how teachers reason about knowledge and how they do this for others.

When researchers focused their investigations on teachers' epistemic cognition, many have done so from the perspective of teachers as learners; that is, how they construct new meaning, knowledge, or understanding for themselves (Ferguson & Lunn Brownlee, 2018; Sosu & Gray, 2012; Yerrick et al., 1997). Investigations have not considered the ways that teachers engage in epistemic processes for others, to create an "epistemic friendly environment" or epistemic cognition aimed at focused learning experiences for students (Barzilai & Chinn, 2018, p. 362). One exception is Feucht's (2017) work, which focused on the classroom level and the generation of a classroom epistemic climate that can emerge from the shared, reciprocal components of teachers' epistemic beliefs, epistemic instruction, epistemic knowledge representations, and learners' epistemic beliefs. Although this framework for epistemic cognition moves beyond the perspectives of individuals to the entirety of the classroom climate, it does not include the kinds of epistemic cognition that teachers must engage in to determine goals, facilitate instruction, or select and use knowledge representations.

5.2. The need for qualitative investigations of epistemic cognition using think-aloud interviews

The prominent research methodology in the field of epistemic beliefs/cognition involves self-report instruments and quantitative analysis of these research data (DeBacker, Crowson, Beesley, Thoma, & Hestevold, 2008; Hofer, 2016). Important associations between individuals' epistemic beliefs and various academic and motivational outcomes emerged from this work (Greene, Muis, & Pieschl, 2010; Muis, 2007, 2008). Yet, many researchers have voiced their concern about relying solely and so heavily on findings from these instruments (e.g., Buehl, 2008; Greene et al., 2008; Hofer & Pintrich, 1997). Their concern stems mainly from consistently low reliability, which weakens the validity evidence for the inferences one can draw from these data (Greene & Yu, 2014; Sinatra, 2016). Other criticisms included: the wording of the items were leading, the focus was on beliefs instead of the processes of epistemic cognition, and the measures were oversimplified (e.g., dichotomizing beliefs into naive and sophisticated (Greene & Yu, 2014; Sinatra, 2016).

At a minimum, findings from self-report instruments need to be triangulated with those gathered using different methodologies to increase the trustworthiness of the claims forwarded. For example, qualitative methodologies have the potential to offer researchers a different lens to examine epistemic phenomena. From this they can garner different insights into how teachers engage in epistemic cognition, and their reasons or explanations for why they evoke specific processes. In particular, qualitative methods such as think-aloud interviews (Ericsson, 2006), semi structured interviews (Feucht & Bendixen, 2010), cognitive interviewing (Barzilai & Weinstock, 2015), or cued reflection (Ferguson, Braten, Stromso, & Anmarkrud, 2013) in which researchers "prompt individuals to surface and reflect on the otherwise nonconscious aspects of their epistemic cognition" may externalize processes that might have otherwise remained internalized using survey methodology (Sandoval, Greene, & Braten, 2016, p. 484).

In this study, we used think-aloud methods to capture teachers' epistemic practices following the work of researchers like Barzilai (2017) and Mason, Boldrin, and Ariasi (2010). Think-aloud protocols are used to access the cognitive processes of individuals engaged in problem solving tasks such as data use and decision making (Ericsson, 2006). During think-aloud interviews, the researcher encourages participants to read their work aloud, describe their thinking and/or interpretations of the work, and elaborate and make their thinking processes explicit. For us, think-aloud interviews were the "right tool for the right job" (Greene, Cartiff, & Duke, 2018, p. 483). Although not generalizable or predictive of the practice of others beyond the sample, think-alouds and other qualitative methods offer detailed and nuanced illustrations of how practices manifest in context. As Chinn and Rinehart (2016) argued, "developing epistemic cognition is less a matter of developing a few sophisticated beliefs and more a matter of mastering a large and integrative network of causal epistemic processes" (p. 471). Because think-aloud methods allow for externalization of teachers' internal dialogue, they allow researchers to capture the practices and processes teachers use when they engage in epistemic cognition. As a result, researchers can glean insight into *how* teachers justify claims, weigh sources of information, evaluate their own and their students' claims, and reason about their knowledge, and their students' knowledge.

5.3. A need for in situ exemplars of practice

Because there is so little research that documents *how* teachers engage in epistemic cognition, the field lacks parsimonious exemplars of how these processes unfold in practice. Such exemplars could be used in teacher preparation coursework and professional learning experiences to illustrate and facilitate discussion of teachers' epistemic practices. Such exemplars need to capture the complexity and situatedness of teachers' epistemic practices, as the nature of one context can encourage one particular way of thinking, and not another (Chinn & Rinehart, 2016). As a result, Kelly (2016) called for examining epistemic practices "in situ" or "in settings where issues of knowing are at stake and in play" (p. 394). Our current work answers this call by forwarding examples of how teachers engage in epistemic cognition for classroom assessment, while recognizing the situatedness of their educational contexts. We believe the nature of classroom assessment tasks, examined as an integrated aspect of teachers' overall classroom practice, can provide authentic contexts to observe how teachers manage multiple knowledge-related aims in practice. To do so we examined seven, fifth grade teachers' reflective self-talk as they interpreted students' work or discussed assessment practices to determine if, and how they engaged in epistemic cognition as part of the interpretation element of classroom assessment. We were guided by the following research question: In what ways does epistemic cognition emerge when teachers interpret student work?

6. Method

We employed a qualitative case study design guided by Stake's (1995) conceptualization of an instrumental case study. Such methodologies are advantageous for exploring why, how, and what questions that seek to understand and explain phenomenon (Keegan, 2011), especially when the focus of the inquiry is teasing out meaning rather than emphasizing control and prediction (Lather, 1992). The unit of

analysis, or case, can be identified as an individual, group, institution, or process (e.g., Baxter & Jack, 2008). A case is "a phenomenon of some sort occuring in a bounded context" (Miles & Huberman, 1994, p. 25). In this investigation, our case was the process of teachers' epistemic cognition (phenomenon) that emerged during the interpretation of student work in English Language Arts (ELA) as demonstrated during a two week period of typical practice and framed by initial and closing interviews (bounded context). We focused on the content context of ELA because it is a state tested subject area and student performance in this area carries high stakes for teachers and learners.

The purpose of an instrumental case study is to provide insight into a phenomenon or to refine a theory (Stake, 1995). We defined our case as instrumental because our participants were selected to provide insight and understanding into the phenomenon of teachers' epistemic cognition during the classroom assessment task of interpreting student work (Stake, 1995). Specifically, we sought out teachers who were recommended as having expertise in classroom assessment, as these individuals may provide greater insight into this phenomenon. Although not generalizable to the practice of other teachers, this in-depth exploration offers a detailed and nuanced illustration of how teachers' epistemic cognition unfolds in the context of interpreting student work.

6.1. Participants

Participants for this study included seven, fifth grade English Language Arts teachers from five school districts in the Northeast, United States (Table 1; all names used are pseudonyms). All participants self-identified as White.

We used the Model of Domain Learning (MDL; e.g., Alexander, Sperl, Buehl, Fives, & Chiu, 2004) and Palmer, Stough, Burdenski, and Gonzales' (2005) two-gate process for identifying experts to select participants for this study. The MDL is a framework that describes the development of expertise from acclimation, through competency, to expertise in terms of teachers' knowledge, strategic processing, and motivation (Alexander & Fives, 2000; Alexander et al., 2004). Additionally, we relied on Palmer et al.'s (2005) two-gate process for identifying experts which requires teachers to have a minimum of three years teaching experience, the requisite degree(s)/certification(s) for their present position (gate 1), and to be recognized by an informed perspective (e.g., principal) as demonstrating expertise on the salient indicators (gate 2). Teachers were nominated by their school principal to be considered for the study using a nomination form based on our study criteria and the two-gate criteria described above. Nominees were interviewed by phone using open-ended questions intended to elicit information on their assessment practices relevant to the domains of the MDL (knowledge, interest, and strategic processing). Using this information, we selected teachers that demonstrated that they had the knowledge, interest, and strategic processing related to classroom assessment to suggest expertise in this area.

6.2. Context of ELA instruction

ELA curricula in the five schools in which participants taught included The Teachers' College Reading and Writing Workshop (N = 3), a Blended approach (N = 3), and a Basal Reader Program (N = 1). We briefly describe each curricula and the major assignments used to assess students' literacy performance. Three teachers (Sparrow, Burke, and Cooper) used Teachers' College Reading and Writing Workshop as their curriculum for ELA. This curriculum included skill-based mini lessons, reading of self-selected texts, and frequent conferencing between the teacher and students (Calkins & Tolan, 2010). Teachers used a weekly Reading Response as a major assignment to evaluate students' literacy skills. The purpose of the assignment was for students to summarize their reading from their just right book applying that week's literacy skill(s) (e.g., synthesis, interpretation). *Just right* books were student-selected books that aligned with students' current reading level (i.e.,

Table 1
Background information: teachers and contexts.

Participant Descriptions	School Context
Daphne Burke 25 years old, Female 4 years teaching experience Bachelor's Degree + additional coursework	*Lincoln Elementary (PK-5)* is located in a small, middle-class town (average family household income: $148,500). According to the publicly available school report card, the school enrolled 343 students, and had a faculty to student ratio of 1:9. The school's ethnic/racial make-up included White (68.2%), Asian (23%), Hispanic (5%), Black (2%), and other (1.8%) students. None of the students were identified as economically disadvantaged, 2.6% of students were identified as Limited English Proficient, and 11.1% were identified as a Student with a Disability
Martin Sparrow Male, 35 years old 12 years teaching experience Master's Degree + additional coursework	
Layla Cooper Female, 48 years old 7 years teaching experience Master's in Teaching	*Washington Elementary School (K-6)* is located in a medium sized, lower to middle class-town (average family household income: $63,000). According to the publicly available school report card, the school enrolled 356 students, and had a faculty to student ratio of 1:14. The school's ethnic/racial make-up included White (60%), Hispanic (20%), Black (9%), and other (11%) students. 9% of students were identified as economically disadvantaged, 9% were identified as Limited English Proficient, and 14% were identified as a Student with a Disability.
Chelsea Lang Female, 29 years old 4 years teaching experience Master's in Teaching	*Jefferson Elementary School (3–5)* is located in a small sized, middle class-town (average family household income: $150,000). According to the publicly available school report card, the school enrolled 435 students, and had a faculty to student ratio of 1:1. The school's ethnic/racial make-up included White (87.1%); Hispanic (6.9%), 3.4% Asian, Black (0.9%), and other (1.7%) students. 6% of students were identified as economically disadvantaged, 3% of students were identified as Limited English Proficient, and 19% were identified as a Student with a Disability.
Wendy Jones Female, 61 years old 11 years teaching experience Master's in Teaching	
Kaylin Murphy Female, 30 years old 7 years teaching experience Master's in Teaching	*Adams Intermediate School (4–5)* is located in a small sized, middle class-town (average family household income: $114,000). According to the publicly available school report card, the school enrolled 274 students, and had a faculty to student ratio of 1:10. The school's ethnic/racial make-up included White (87.2%); Hispanic (6.6%), Black (0.4%), and other (5.8%) students. 11% of students were identified as economically disadvantaged, no students were identified as Limited English Proficient, and 20% were identified as a Student with a Disability.
Tatiana Hagerty Female, 48 years old 25 years teaching experience Master's in Teaching	*McCain Elementary School (K-5)* is located in a medium sized, middle class-town (average family household income: $117,000). According to the publicly available school report card, the school enrolled 396 students, and had a faculty to student ratio of 1:14. The school's ethnic/racial make-up included White (58.8%); Hispanic (7.3%), Black (2.5%), Asian (26.8%) and other (4.6%) students. 1% of students were identified as economically disadvantaged, 7% were identified as Limited English Proficient, and 21% were identified as a Student with a Disability.

Note: All names used are pseudonyms.

Lexile score) and were used for independent or paired reading. The format for each Reading Response included: background information about the self-selected text, evidence of that week's literacy skill, a conclusion, and a prediction of future events. Teachers used a rubric to provide a score/grade for each Reading Response.

Three teachers (Hagerty, Lang, Jones) incorporated elements from several literacy curricula (which we referred to as a blended approach), instead of implementing a single curriculum. Hagerty, for example, used Reading Responses as a major literacy assignment, although she did not use the other assignments that are part of Reading and Writing Workshop (e.g., post-its). Similarly, Lang and Jones routinely conferenced with individual students and small groups of students. These teachers used conferences as a space to advance students' progress on that week's literacy skill(s), by either providing instructional feedback on student performance on an assignment or by scaffolding students as they practiced that skill on a current task. In both cases, the teacher observed students' progress on the literacy skill and recorded his/her observations in conference notes. Conference notes were stored as electronic files or handwritten notes in a binder and used to determine individual student feedback or future instructional interventions.

In addition to conference notes, Lang and Jones also used two spelling and vocabulary assignments as part of a weekly vocabulary unit. Students received a list of 12 vocabulary words (e.g., accomplish, civilian) at the beginning of the school week. For one weekly assignment, students were given the vocabulary words in a word bank and had to write a paragraph incorporating those words. For the second weekly assignment, students had to correctly spell and use each vocabulary word in a sentence.

Murphy used a basal reading program focused on developing students' decoding, phonemic awareness, and word attack strategies. The elements of this program included spelling tasks, flash cards, and constructing sentences using sentence strips. Similar to Lang and Jones, Murphy used a weekly vocabulary assignment to assess students' spelling and comprehension of ten terms. To summarize, the participants in our sample used Reading Responses, Conferencing, and Vocabulary assignments to assess their students' literacy skills.

6.3. Data collection

Intensive data collection for this project spanned from late September (end of the first month of school) through early February, with a closing interview held in June (end of the school year). Table 2 illustrates the overall timeline for data collection as well as details regarding the number, length, and focus of the interviews. Two members of the research team conducted an initial interview (II) with each teacher from late September through early November. Then, from mid-November to early February each teacher participated in a data collection cycle that we anticipated to take two-weeks per teacher. However, due to school holidays, weather events, and the pregnancy of one of the researchers, these cycles were expanded for a few participants (i.e., Burke, Hagerty, & Sparrow).

Each cycle consisted of two to three days of classroom observations, and four to eight think-aloud interviews (TA) focused on teachers enacting their assessment and instructional planning activities for ELA. Because we followed the schedule and availability of each teacher we reference the interviews that occurred each day during the data collection cycle as one interview. Thus, depending on the teacher, this interview may have occurred in segments across the school day. For example, on January 28th, we attended Ms. Cooper's class and observed her ELA instruction from 8:30 to 10:30 am. Her planning period began at 10:30, which is when we began the TA with her on her ELA planning and assessment practices, about 13 min into the interview, as she was explaining a rubric that she would use, she realized she needed to go make copies, thus the interview stopped. When she returned with the copies we began again with a brief (3 min) explanation of the rubric when Ms. Cooper remembered that she needed to call a parent and the interview stopped again. Following the phone call we had another 16 min of interview about the assessment tool before the students returned to the classroom (11:15) and our observations of class instruction resumed. Students had lunch from 11:30 to 12:20, during this time we continued the think-aloud interview for 42 min. After lunch, we observed the ELA instruction with Ms. Cooper's second class through the end of the day and dismissal activities.

Finally, at the end of the academic year, we conducted closing interviews (Closing Interview, CI) with all teachers who participated in the study. Throughout all data collection activities we did not prompt teachers to engage in epistemic cognition, nor did we explicitly ask them to reflect on their epistemic practices or beliefs. Instead, we observed these processes unfold naturally as teachers engaged in their everyday work.

6.4. Data sources

Think-aloud interviews (TA). Within a two week time span, we asked to be present whenever teachers engaged in classroom assessment or instructional planning activities related to ELA. During these sessions, research team members followed the think-aloud interview protocol in Appendix A. We first introduced teachers to the concept and goals of the think-aloud interview and then following the protocol prompted teachers to think aloud while they performed these tasks. All of the think-aloud sessions were audio-recorded and transcribed following a naturalized transcription method. Naturalized transcription

Table 2
Data collection timeline and topics.

Teacher	Interviews				Think Aloud Interviews (TA)								
	Initial (II)		Closing (CI)		Timing				Focus of Think Aloud				
	Date	Min	Date	Min	Week Starting Monday:	Days	Min	Average Min Per Day	Explanations	Creating Assignments	Interpreting Student Work	Instructional Planning	Team Planning
Tatiana Hagerty	Oct 20	110	Jun 17	93	Nov 10	5	485	97		1	3	1	
Kaylin Murphy	Oct 17	40	Jun 22	21	Nov 10	8	579	72.3	2		6		
Chelsea Lang	Nov 3	60	Jun 15	81	Dec 1	4	337	84.25	1		3		
Martin Sparrow	Oct 29	95	Jun 15	70	Dec 1	6	273	45.5	2		3.5	0.5	1
Wendy Jones	Nov 4	124	Jun 15	69	Jan 5	7	285	40.7	1		5	1	
Daphne Burke	Oct 15	35	Jun 15	70	Jan 5	5	187	37.4	1		3		
Layla Cooper	Sep 26	48	Jun 16	73	Jan 26	5	338	67.6	1		4		
Total		512		477		40	2484		8	1	27.5	2.5	1
Mean		73		68		5.7	356						
Range		35–110		21–93		4–8	187–579						

"occurs when written features of discourse have primacy over the oral" and include the transcriber adding punctuation where it is needed and omitting "ums" and "ers" that may make the transcript "odd looking" or "hard to read" (Bucholtz, 2000, p. 1461).

Classroom observations. Research teams conducted two to three days of classroom observations in each classroom. These observations allowed the researchers to view the teachers and their instructional practices in a naturalistic context and obtain a first-hand encounter with the phenomena under study (Merriam & Tisdell, 2016). During observations, the researchers collected detailed field notes of assessment-related activities and contextual routines by completing a session overview, a description of the context, and a running record.

Initial/closing interviews. Teachers were interviewed twice. The focus of these interviews was on assessment practices at the classroom, school and district levels and addressed (1) teachers' assessment practices including types of assessments they used during instructional planning and student evaluation and the ways in which they relied on assessment data to inform their instruction and (2) perceived supports and hindrances for assessment at school and district levels. The closing interview allowed us to engage in member checking and ask follow-up and clarification questions to teachers based on our ongoing analysis of the data gathered in the data collection cycles.

Material artifacts. We collected material artifacts to support our understanding of teachers' assessment practices. The artifacts included digital copies of student assessments, records of student data, planning materials, and any other related instructional materials. Artifacts were photographed or scanned with student identification hidden. When referred to during a think-aloud interview they were noted so that the artifact could be aligned with the teachers' interview data at a later time.

7. Analysis

Following Braun and Clarke's (2006) six analytic steps, we used thematic analysis with recursive emergent coding to analyze the data (Miles, Huberman, & Saldaña, 2014). Data refers to the transcripts from the initial, closing, and think-aloud interviews. We referenced the field notes and material artifacts to contextualize and help us understand the interview data.

First, we read the data multiple times, constructing memos describing the processes teachers enacted when they interpreted student work. At this point, we did not attempt to determine if particular actions were epistemic or not; our goal was to understand teachers' practices without imposing a particular lens. Second, we conducted initial coding according to epistemic processes identified in Chinn et al. (2014) and Fives et al. (2017). In our first attempt at coding, we focused on identifying when teachers set epistemic aims for themselves or their students. An aim was epistemic when their goal "focus(ed) on developing representations that capture(d) in some way how the world is (K. Z. Elgin, personal communication, February 1, 2013)" (Barzilai & Chinn, 2018, p. 357). In our code book we specified the following to underscore what we meant by epistemic aims for self: goals related to figuring things out and forming his/her own beliefs and knowledge. Epistemic aims for learners were identified when the goal named indicated the pursuit of knowledge construction, justification, or understanding. Once we identified an epistemic aim, we coded any reliable processes teachers used to "successfully achieve those epistemic aims or produce epistemic products" (Barzilai & Chinn, 2018, p. 357), the ideals teachers' referenced to assess the products of their epistemic cognition, and the final epistemic product or end. Of note, there was a close relationship between reliable processes and ideals, such that reliable processes were often used to facilitate the attainment of ideals. Our team met regularly to discuss codes with active referencing to the literature to help us distinguish epistemic from non-epistemic processes.

In a second round of coding, we identified examples of reliable processes and ideals that appeared to be epistemic, but in which the teacher did not state the epistemic aim that led to that particular process. In some instances we could infer an epistemic aim from teachers' descriptions of their epistemic ends or products, and in other instances we used the closing interview and member checks to confirm or disconfirm our inferences. Still there were times when a process appeared to be reliable but we could not be sure, and so it was not included. Table 3 illustrates our thematic codes, definitions, and examples.

Third, we identified categories of codes which we referred to as themes. Fourth, we referenced the extant literature again as we discussed each theme and described its underlying assertions. Fifth, we used this information to construct microanalytic reports in which we described our themes, notated examples of chunks of data with varied

Table 3
Codebook.

Component of Epistemic Cognition	Definition	Examples
Epistemic aims	Knowledge-related goals	[For Learners] "their writing task is going to be, they read an article about cats and dogs and then there's a bunch of facts about cats or dogs, and they have to choose which one makes a better pet… and it has to be five paragraphs and they have to give reasons and details in each of their paragraphs and have an organizer" (Murphy_TA_11/12). [For Self] "And that's really what assessment is for. So that I know that they're making progress. They may not be on fifth-grade level. They may not be internalizing all of your teaching, but they've made progress, and that's all we can ask of them to do, I believe" (Jones_TA_1/5).
Epistemic ideals	Criteria or measure by which individuals assess the product of epistemic cognition	"Um, she made a good prediction at the end of that. And then she used real life experiences to help her so that's good" (Burke_TA_1/13_RR).
Epistemic reliable processes	Strategies that individuals use to achieve knowledge or any other epistemic aims.	"Sometimes I'll write in my conference log, even if I'm not conferencing with them. I'll put "NC" [for next conference] next to the student's name. But I'll still make myself notes, things I want to know, like 'this child really does not use transitions correctly.' And then, like also, when we're doing revising and editing centers I'll sit at one center, so if I notice that, you know, seven of the kids are really struggling with transitions, I'll make sure I like hit that" (Lang_TA_12/8_CN).
Epistemically informed praxis	Result of epistemic cognition; reflects the identified epistemic aim (or a re-defined aim)	[For Learners] "I'm circling what he's spelling wrong. I'm not taking points off, but I am going to bring it to his attention, because we're going do another project in a couple of weeks, and I will take points off" (Jones_TA_1/13). [For Self] "I'm looking for why they picked [this answer]. I'm trying to understand why they answered this…duplicate birth certificate and they picked hidden birth certificate. So I don't know why they picked it, I was just trying to understand why they did that" (Lang_TA_12/8_CN).

epistemic practices, and described/elaborated on our findings. Following these steps we re-engaged with our research question and sought ways to organize and present our findings that best represented our data and analyses. This resulted in the generation of this manuscript as step six, generating the report.

Trustworthiness of the analysis was addressed through triangulation of data, using our research teammates as critical friends to interrogate the data and our analysis processes, conducting member checks with the teachers in follow-up email correspondence, and establishing and maintaining a clear audit trail from data to themes (Creswell & Miller, 2000; Lincoln & Guba, 1985). Denzin (1978) identified four types of triangulation: data, investigator, methodological/analysis, and theoretical. Triangulation of data "combines data drawn from different sources and at different times, in different places or from different people" (Flick, 2004, p. 178). Thus, in this investigation we gathered data using similar collection procedures across different participants and in different classrooms and school contexts. Specifically, we looked across all teachers' data to ensure that our evidence of teachers' epistemic cognition manifested across interview types (initial, think-aloud, closing) and study participants.

8. Results

Our results are organized in two sections. We first offer a description of the components of epistemic cognition as revealed across teachers in this investigation. Second, we provide an excerpt of one microanalysis for one teacher to illuminate the ways that epistemic cognition emerged in situ. To help the reader track the data sources for each excerpt we labeled them using this format: participant (last name), data source (II: Initial Interview; TA: think-aloud, CI: Closing Interview), date, and when appropriate, the nature of the assignment (RR: Reading Response; CN: Conference Notes; and VA: Vocabulary Assignment).

8.1. The components of epistemic cognition in teachers' interpretation practices

In order to illustrate how epistemic cognition emerged in these teachers' interpretation practices we describe and provide examples of the components of epistemic cognition. We do this to show the epistemic nature of these teachers' work and the variety of aims, reliable processes, ideals and ends that emerged across these participants. While we offer descriptions of each component, it is important to note two things. First, the epistemic processes did not occur in isolation, but were part of a larger activity or thinking process. Second, and related to that issue is the need to recognize the highly contextual nature of these components in practice, such that an aim, reliable process, or ideal in one interlude may be epistemic - in one activity and not in another. That is, the activity itself does not determine "epistemic," rather the use of it in context determines this. We provide examples of this below.

We found evidence of epistemic cognition enacted by all teachers as they evaluated epistemic matters. However, we also found evidence that teachers developed aims, used reliable processes, and held ideals that were not epistemic in nature, we describe these briefly for two reasons. First, non-examples of a phenomenon or concept help to clarify the parameters of any given category or set of ideas (e.g., Tennyson & Park, 1980). Second, we sought to be transparent about the actual practices that teachers enacted and recognize that not all classroom assessment practices engendered epistemic cognition. Because our goal was to describe examples of the components of epistemic cognition, the examples provided here should be viewed as instances of the phenomenon, not evaluative of any particular teacher.

Aims. In the practice of teaching, epistemic aims can be set by teachers for their students and for themselves (Buehl & Fives, 2016). When teachers set epistemic aims for their students, they are stating the epistemic goals they have for students. For example, Ms. Hagerty referenced an epistemic aim for her students' reading response assignment when she noted, "…they were to summarize based on the work… summarize the action you see the character do" (Hagerty_TA_12/1_RR). This was an epistemic aim for the students because it set a knowledge-focused goal for the learners to consider essential ideas from a text to produce a concise, meaningful reading response using the cognitive skill of summarizing. Another example in which a teacher had an epistemic aim for students occurred when Ms. Cooper graded reading responses. She stated,

> The point of this [reading response assignment] is to prove their reading comprehension when they are reading independently. So, all of the things I model when we are doing read aloud, and all the things we model when we are together for our literature circles, I want them to prove it in here. So, I'm looking for detail and accurate character traits, predictions, summaries (Cooper_TA_12/1_RR).

Ms. Cooper had an epistemic aim for her students to demonstrate reading comprehension by providing detailed and accurate character traits, predictions, and summaries in their reading response.

In addition to setting epistemic aims for students, teachers also set epistemic aims for themselves, as learners, related to knowing or understanding their students' knowledge. For example, as Ms. Burke evaluated students' reading responses, she stated,

> Looking at their nightly homework assignments…[is] another way for me to understand, because there are so many of them [students] that I am not able to conference with them every day, so it is like I am in their head. So it's just a way for me to kind of document and understand how they are doing (Burke_TA_1/15_RR).

In this excerpt, Ms. Burke set a goal for herself to understand students' reading comprehension by reading their weekly reading response assignments. Similarly when grading a reading response assignment, Ms. Cooper stated, "(I) have the documentation…I think [I am] using it right now, more so, to learn about the [reading] program, learn what the kids can do (LC_TA_1/25_RR).

Teachers also had aims that were not epistemic. Non-epistemic aims for students reflected goals related to routines or managerial tasks such as formatting, documentation, or homework collection procedures. For example, Ms. Hagerty expressed a non-epistemic aim for her students related to formatting their reading response assignment. She stated, "So there is that element, the setup, so when I go through these, I expected to see the title of the response, title of the book, and all the components of the chart" (Hagerty_TA_12/1_RR). Because formatting expectations did not require students to consider epistemic matters, such as the nature, source, structure or justification of knowledge or as a means to represent the students' understanding of the world, we identified this as an example of a non-epistemic aim set by the teacher, for the learner. Teachers also set aims for themselves that were non-epistemic. For example, Ms. Jones stated the following while grading a vocabulary assignment, "So I'm just going to look at the words and the sentence at the same time… so I get it done fast" (Jones_TA_1/7_VA). Because speed is not a knowledge-related goal, Ms. Jones' aim for herself was non-epistemic.

Reliable processes. Teachers developed or selected reliable processes for their students to support the students' achievement of teacher developed epistemic aims. For example, in her initial interview Ms. Jones described a reliable process she taught students to track different types of revisions to their work. Here, we inferred that she had an aim for students to develop writing skills with attention to style, spelling, punctuation, and grammar. To achieve this aim, she taught students to use several reliable processes. In addition to using a peer review checklist, she also asked students to code their revision and edits. She described, "So they use a different pen color, they have to use black for revising, and they have to use red for editing" (Jones_II_11/4). In this context, revising referred to issues of style such as word choice (e.g., increasing vivid words) whereas editing referred to spelling, punctuation, and grammar. The use of different colored ink to revise and edit

their reading response papers was seen as a reliable process for students because the intention of this process was to help students track their revisions and develop habits of good writing. This reliable process for students also helped Ms. Jones track the number and kinds of edits students made to their work as she evaluated their progress. As such, a reliable process intended for students, also helped Ms. Jones achieve her epistemic aim of understanding students' progress.

Another example of teachers' reliable processes to support their achievement of epistemic ends for themselves, is seen in the excerpt below from Ms. Lang. Here she described how she used reliable processes to consider the vocabulary quiz results in relation to the progress of her teaching and to inform her practice. Referring to students' results she remarked:

> **Lang**: I feel like all the time I'm looking at my data…and I kind of break it down by percentages, you know informally, and I sort [the vocabulary quiz scores] when I grade them. If 85% of my students got Ds, obviously I did something wrong, and vice versa, if 85% of my students got A's, I, you know, rocked it. So, I calculate those kind of percentages a lot to see if I missed something, if they missed something, or if I'm missing a piece somewhere…well that student was sick for a week so that makes sense that he does not get it.
> **Interviewer**: So what I am hearing you say is that you look at both: individuals and the whole [class].
> **Lang**: Both, and you do that all the time, like I just showed before, like vocab she's making steady growth. As a class, I know my vocab unit is working because 90% of the students are getting A's and B's. You do it both ways. (Lang_II_11/3_VA).

In this example, Ms. Lang referred to reliable processes she used to monitor her teaching and individual student progress. By regularly considering the percentages of students scoring at different levels she used that information to support her knowledge of her students and curriculum. In addition, while looking at the overall distribution of grades across the class she tempered this analysis by including other relevant information, such as, knowing that a student missed a week of school and using that to understand the reason for a low score. Note, we inferred that she implemented these reliable processes because she held ideals with respect to what the outcomes of quiz scores meant for her practice. That is, she seemed to use reliable processes in order to ascertain if her ideals were met. This underscores the interrelationships that exist in tandem among the components of epistemic cognition.

Teachers used reliable processes to reach non-epistemic ends. For example, Ms. Lang described a reliable process she used to keep track of grades in the online grading program. She explained, "The colors are what I code it, so blue is vocabulary, and that's just me. Contracts are orange, classwork's purple" (Lang_TA_12/1). In this example, the color-coding process was a reliable way for the teacher to distinguish assignment grades at a glance, yet the reliable process was not intended to achieve an epistemic end. However, as with the students, such a process may have supported Ms. Lang in pursuing an epistemic aim if she analyzed this data by assignment type for individual or group trends in order to *understand* student progress.

Here it is worth noting that we coded the color coding that Ms. Lang did in her gradebook to highlight different assignments as a non-epistemic reliable process, at the same time in Ms. Jones' excerpt above we indicated that the color coding she required her students to engage in while reviewing their own work was an epistemic reliable process. We determined whether or not a particular activity/process was epistemic or not based on the aim associated with the process at the time we observed it. In the case of Ms. Jones' students, the aim she identified for her students was to construct an understanding of the writing process as one that involves editing (grammar/punctuation) as well as revising (e.g., word choice, transitions). In contrast, Ms. Lang color coded her gradebook assignments so that she could locate information more quickly in the future. At some future point, the color coding may assist her with an epistemic aim, but in this particular instance of her work, she was not pursuing an epistemic aim, therefore this process was not considered to be epistemic in nature.

Ideals. Teachers used ideals as standards of evaluation. Ideals were considered epistemic when they reflected beliefs about the knowledge or subject matter relevant to the student's work. Teachers referenced epistemic ideals they held about reading/writing to understand and evaluate student work. For example, Ms. Cooper referenced epistemic ideals when she evaluated students' reading responses. She noted:

> So what I noticed she was doing, she doesn't know-she took these words directly from the book, and so she is putting it in a quotation, indicating that it's someone's words, but she never told [me] where it came from. So she just needs to be taught that if she's going to do that, then she needs to say, 'So according to the book such-and such' and then she could use those quotations. She just does it because she knows she can't plagiarize, she can't copy word-for-word. So she just needs to be taught kind of how to take a direct quote and either say, 'Benjamin Franklin said'… so she just needs a little on how to do it. (Cooper_TA_2/6_RR).

Here we inferred that Ms. Cooper holds an ideal that direct quotes require a reference to who stated the quote in addition to placing quotation marks around the cited text to avoid plagiarism. That is, appropriate use of quotations in writing involves more than just copying from the original text and adding quotation marks. Rather, to do this in writing, students need to integrate the quotation into the flow of discussion. We inferred that this was an epistemic ideal because integrating the quote in text goes beyond a simple issue of formatting a citation. Further as indicated, she used this ideal in her interpretation of students' reading responses.

It should be noted that this ideal was tempered by her knowledge of curriculum and the developmental trajectories of her students. Following the excerpt above Ms. Cooper elaborated:

> And so basically what I'm saying is, if this was a direct quote, you need to include who said it. Otherwise, restate the fact in your own words, which is really, probably, where they're at more developmentally, they haven't been taught any of those [skills] how to cite, like how to use APA or MLA, like they don't know that yet, so for them, the best strategy would be just restate it in your own words. That's hard to do, but they need that skill, so that's generally what we're teaching them at this age. (Cooper_TA_2/6_RR).

Ms. Cooper indicated that students need to develop the knowledge of how to correctly cite or alternatively use a restating strategy, which is the current target of instruction at these students' current level. This illustrates the ways that teachers temper their ideals to match the students' current level. For students, half way through fifth grade (≅10.5 years old) an ideal she held for their writing was to restate the work in their own words; but she was also aware that the next step is for them to use citations appropriately.

Non-epistemic ideals emerged in teachers' beliefs about products or actions that were not knowledge-related. Common non-epistemic ideals reflected standards for presentation or formatting and not those related to knowledge or understanding. During the think-aloud interview with Ms. Hagerty for example, she expressed that reading responses should be "neat" (Hagerty_TA_12/1_RR), which represented an ideal, but one that was not epistemic in nature. We also saw instances where non-epistemic ideals reflected the teacher's larger belief system or goals. Ms. Jones exemplified this when she evaluated students' vocabulary assignment and noted that a student had not used a word correctly in a sentence (relying on an epistemic ideal for the word's meaning and use). However, she decided not to deduct points for this particular error stating, "I don't want them to be reluctant to take chances" (Jones_TA_1/7_VA). Thus, Ms. Jones seemed to hold a non-epistemic ideal related to student motivation that guided her practice. The emergence of non-epistemic ideals and aims in the process of analyzing student work demonstrated that not all aspects of evaluating student

work were epistemic in nature for the teachers in this study.

Epistemic ends. For the teachers in our study, engaging in epistemic cognition resulted in one (or both) of two types of epistemic ends. The first type of epistemic end was an epistemic stance, which occurred as a result of a teacher engaging in epistemic cognition for him/herself. The second type of epistemic end was the practical application of the results of epistemic cognition to teaching: *epistemically informed praxis*. As with aims, reliable processes, and ideals, we identified ends that were epistemic and non-epistemic.

An epistemic end for teachers is referred to as an epistemic stance. This occurred when they engaged in epistemic cognition to reach a knowledge-related goal for self. For example, while reviewing students' responses to a vocabulary assignment, Ms. Murphy indicated that her goal was to understand her students' strengths and challenges. Her reliable process was to ignore the rubric and spot check students' papers. She did this to achieve her aim of getting a sense of where her students were at the onset of this unit. We saw evidence that Ms. Murphy reached an epistemic end, an understanding of her students' progress.

More common in these data were epistemic ends that related to the teacher's practices, referred to as epistemically informed praxis. Epistemically informed praxis emerged in discrete responses such as when teachers made comments on student work and as a part of more complex decisions such as to re-teach or re-design a lesson or assignment. For example, Ms. Lang described how she changed the word bank in a vocabulary assignment for her English Language Learners (ELL) based on student performance from the previous year:

> A modification I will do in the word bank for my ELL students, I will get rid of the extra ones [words] for them…like if it is apparently, instead of apparent, I will change it for them and get rid of the extras (Lang_TA_12/8_VA).

This is an example of epistemic praxis because it required the teacher to modify the vocabulary assignment to meet her students' needs based on her understanding of these learners and her prior experience using this assignment.

Non-epistemic ends also emerged as teachers interpreted student work. An example of a teacher who had a non-epistemic stance for herself was presented above in the example of Ms. Jones. Recall that she wanted to get through the stack of papers quickly. Mrs. Jones achieved that end (to get through papers quickly), but this did not result in an epistemic stance, because she did not develop an understanding of student progress. Teachers also had non-epistemic ends related to practice. These typically included ends related to organizational and managerial tasks. For example, Ms. Murphy explained, "I put a star or a C on it; so they know that I checked it" (Murphy_TA_11/13_VA). In this example, Ms. Murphy's end was non-epistemic because it was not knowledge-related. She marked her students' copies as a form of communication to indicate that they were checked.

In the sections above we provided examples of the components of teachers' epistemic cognition when they engaged in classroom assessment, and examples of the types of epistemic ends that resulted from teachers engaging in epistemic cognition. We also included examples of the classroom assessment tasks that teachers enacted that were non-epistemic. We described each component independently to clarify the nature of each and to evidence the engagement of epistemic cognition across teachers engaged in assessment activities. However, these components are part of an interdependent process such that aims influence choice of reliable processes, which facilitate ideal use, in order to evaluate epistemic matters and lead to epistemic ends. In the next section we provide a microanalysis to make this interdependent process visible.

8.2. The process of teachers' epistemic cognition in situ

To understand epistemic cognition in teachers' practice, we engaged in a microanalysis of all teachers' interpretation of students' writing. Here we present one excerpt from one microanalysis to illustrate one teacher's evaluation of a single student's Reading Response assignment. We selected this excerpt for three salient reasons. First, it provided a clear depiction of how epistemic cognition is enacted in situ. Second, this brief excerpt utilized the majority of our thematic codes and highlighted the processes revealed across the microanalysis. Third, this excerpt included a range of competing thoughts and considerations that teachers demonstrated when engaged in classroom assessment.

The context of this excerpt was a think-aloud interview with Mr. Sparrow during which he evaluated a set of Reading Response assignments. Fig. 1 is an example of a reading response completed by one student, Anna. Anna's just right book was *Esperanza Rising* (Ryan, 2000).

Mr. Sparrow followed a similar reliable process for evaluating all students' papers. For each student he completed a first read of the student's work where he added comments and looked for skill use. Following this, he conducted a second read of the student's work using the evaluation rubric that coincided with the reading program to assign a score. His first read was geared towards his own understanding of the student's competence and progress (i.e., an epistemic aim for self) and findings were used primarily to guide future instruction (i.e., epistemically informed praxis). In contrast, the second read was targeted towards providing a summative score. The excerpt we describe here is from his first read of Anna's work (Fig. 1; Sparrow_TA_12/3_RR).

Figs. 2–6 provide an illustrative example of our microanalysis; chunked into manageable parts for this reporting. The think-aloud excerpt took approximately six minutes for the teacher to complete in real time, while prompted to think and read aloud as he worked. The format of each figure is the same: In the far left column are excerpts of Mr. Sparrow reading the student's work (Kristen ITC font). The center of the figure is Mr. Sparrow's reflective self-talk (Arial font), in the right of the figure are our analytical notes (Times New Roman font), and the far right column provides row numbers to indicate the horizontal line in the figure that includes the chunk of data and analysis we refer to in the descriptions that follow. Please note that in the analysis column we distinguish between class-focused cycles of epistemic cognition (bold, left justified) and learner-focused cycles of epistemic cognition; which we discuss in the next section.

Cycles of epistemic cognition. We use the term cycle to describe engagement in the process of epistemic cognition. These cycles focused on different grain sizes of learners (i.e., class, individual student) and epistemic matters (e.g., understanding how the whole class performed on a given assignment, developing knowledge of content or the curriculum). Although we saw evidence of cycles across all teachers, such as Ms. Lang's explicit statement of looking at class percentages on tests as a reliable process to understand both individual students and whole class performance, this longer excerpt allows us to demonstrate the fluidity with which this happens. As we move through our description of Figs. 2–6 these cycles repeat between class-focused and learner-focused cycles of epistemic cognition.

When Mr. Sparrow was concerned with the overall progress of his entire class, we identified this as engagement in a *class-focused cycle of epistemic cognition* (Fig. 2, rows 1–2). As he began his analysis of student work he articulated an epistemic aim he held for the class, or all learner**s**: he wanted them to "talk about the type of conflict…in their book" (Sparrow_TA_12/3_RR). In row 2, Mr. Sparrow described an epistemic aim he had for himself; to develop an understanding of learners' progress in understanding conflict. Both of these reflected a class-focused cycle of epistemic cognition related to the task of interpreting this set of students' reading responses.

The *learner-focused cycle* of epistemic cognition, emerged when Mr. Sparrow considered a particular student, Anna, and interpreted her work. At the end of Fig. 2 in row 4, he articulated two epistemic aims: one for himself to understand Anna's progress and one for Anna to understand conflict. The aim for Anna is inferred based on the overall aim for the class and Mr. Sparrow's statement that he was looking for

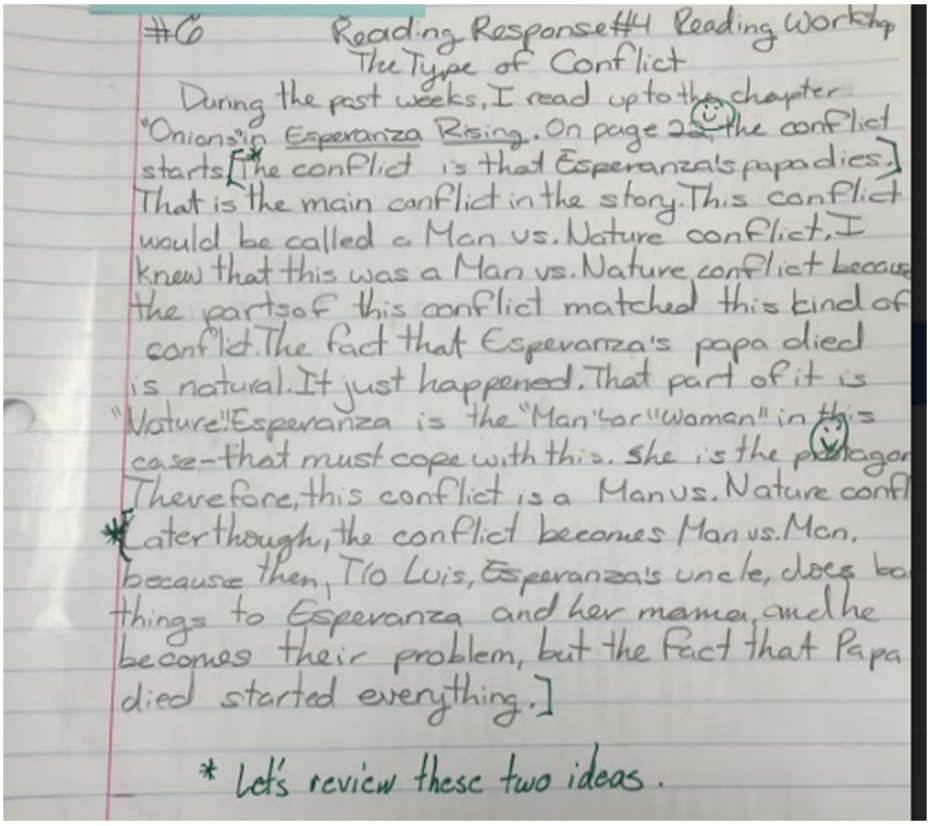

Fig. 1. Sample student reading response (Anna).

her understanding of conflict. Which suggested that this was an epistemic aim he had for Anna.

In-progress epistemic praxis; shifting focus. The learner-focused cycle of epistemic cognition that occurred throughout this micro-analysis was guided by Mr. Sparrow's aim to evaluate Anna's understanding of conflict as illustrated in Fig. 2. In Fig. 3, this cycle continued as Mr. Sparrow engaged the epistemic reliable process of re-reading to consider Anna's work in relation to an unstated epistemic ideal (rows 6–7). Mr. Sparrow used re-reading as an epistemic reliable process to ensure the accuracy of his own understanding of Anna's work. Rather than making an initial judgment, Mr. Sparrow paused and re-read her writing, taking time to fully understand the ideas she presented. We described the ideal he used as *unstated*, because it was clear that Mr. Sparrow held an internal stance that was not met by Anna in her sentence regarding the main conflict in the story.

In Fig. 3, there are two instances of in-progress epistemically

Cycles of epistemic cognition

Teacher reading student work	Teacher reflective self-talk	Analysis Class-focused Cycle Learner-focused Cycle	Row
I'll make notes as I go, but what I'm really looking for is, so they had to talk about the type of conflict they had in their book		**Epistemic Aim for Learners**[1]	1
	and that'll tell me a lot about whether they are understanding where the conflict is and things like that	**Epistemic Aim for Self**	2
[Looking at Anna's Reading Response; Figure 2]	she has the proper heading	Non-epistemic Ideal[2] (Inferred Non-epistemic Aim for *this* Learner)	3
	so I'm looking for her understanding of conflict, so	Epistemic Aim for Self Epistemic Aim for *this* Learner	4

[1] In all cases the aim refers to the Teacher's aim for the student(s) or himself
[2] In all cases the ideal is a belief or knowledge stance held by the teacher.

Fig. 2. Cycles of epistemic cognition.

In-progress epistemic praxis; shifting focus

Teacher reading student work	Teacher reflective self-talk	Analysis Class-focused Cycle Learner-focused Cycle	Row
During the past weeks, I read up to the chapter "onions" in Esperanza Rising. On page 22 the conflict starts			1
	I like that because she's showing text evidence, so specific text evidence, so that's a good sign	Tangential Epistemic Ideal (Inferred Tangential Epistemic Aim for Learner)	2
	[adds smiley face next to page number]....	In-progress Epistemically Informed Praxis	3
	So if it's something really, really big, I'll write a note, if it's just something quick, that I like that they're doing, they're used to seeing like a smiley face or a check or a quick word from me.	**Justification of Practice**	4
The conflict is that Esperanza's papa dies.			
	Eeeeevery story we read this year is about a parent death. It's rough. It's always a bit- with Bridge to Terabithia, fifth grade...	**Tangential Consideration of Knowledge**	5
	so she's saying [rereading]	Reliable Process (rereading)	6
That is the main conflict in the story.			
	So that concerns me, so she's saying	Unstated Epistemic Ideal	7
The conflict is that Esperanza's papa dies. That is the main conflict in the story. This conflict would be called a Man vs. Nature conflict. I knew that this was a Man vs. Nature conflict because the parts of this conflict matched this kind of conflict. The fact that Esperanza's papa died is natural. It just happened. Esperanza is the "man" or "Woman" in this case – that must cope with this. She is the protagonist.		Reliable Process (continued)	8
	So I like that she used protagonist. I'm liking that she's using appropriate vocabulary.	Tangential Epistemic Ideal (Inferred Tangential Epistemic Aim for Student)	9
	[adds smiley face next to term]	In-progress Epistemically Informed Praxis	10

Fig. 3. In-progress epistemic praxis; shifting focus.

informed praxis that revealed micro-cycles of epistemic cognition within the learner-focused cycle; these are seen in rows 1–3 and 8–10. The first instance illustrates the epistemic cognition components of aims, ideals, and ends (Fig. 3, rows 1–3), and the second example shows evidence of a reliable process (Fig. 3, 8). In both examples, Mr. Sparrow considered Anna's knowledge representation (her work), compared it to a tangential epistemic ideal, considered the epistemic matter, and engaged in epistemically informed praxis by providing feedback (i.e., a smiley face). We see this as a micro-cycle because Mr. Sparrow engaged aims, ideals, and a reliable process that resulted in: in-progress epistemically informed praxis. This praxis was *in-progress* as it occurred within the overall cycle of evaluating Anna's understanding of conflict. Thus, Mr. Sparrow's decision to provide feedback illustrated that multiple mini-epistemic ends occurred along the path to achieving a stated aim.

However, Mr. Sparrow's engagement in these micro-cycles of learner-focused epistemic cognition was sparked by epistemic ideals tangential to the stated aims related to the learners' understanding of conflict and his own understanding of student progress toward this aim. In Fig. 3, row 2, Mr. Sparrow remarked on Anna's use of text evidence and in row 9 her use of appropriate vocabulary. These ideals were epistemic in nature as they directly related to the domain of reading comprehension, which was the overall context of this assignment. That Mr. Sparrow recognized Anna's use of other relevant skills in the context of evaluating her understanding of conflict, demonstrated his knowledge of the curriculum (from his self-system) as well as his practice of engaging in ongoing consideration of students' developing skills; possibly another cycle of epistemic cognition occurring over a larger span of task and time.

Amidst the cycle of epistemic cognition focused on the work of this learner, Mr. Sparrow also considered epistemic matters at the class level (Fig. 3, rows 4–5). For example, in the fourth row, Mr. Sparrow justified his practice of drawing a smiley face on Anna's work by referencing a class level practice stating "they are used to seeing a smiley face, a check, or a quick word from me" (Sparrow_TA_12/3_RR). Thus, when Mr. Sparrow provided a justification for his teaching practice this was considered a justification of his teaching knowledge, something that teachers like Mr. Sparrow hone and develop everyday through reflection on experiences.

While reading in Anna's paper that the father of the main character of her book dies, Mr. Sparrow commented that much of the reading curriculum in fifth grade was about the death of a parent (Fig. 3, row 5).

Justification of reliable process

Teacher reading student work	Teacher reflective self-talk	Analysis Class-focused Cycle Learner-focused Cycle	Row
	And what I usually do is I try to read through all the way first, because if I stopped right there on this line,	**Reliable Process** (read all the way through)	1
That is the main conflict in the story. This conflict would be called a Man vs. Nature conflict.			2
	What I would do is say 'Well, how do you explain this?" but in a couple sentences later she says	Justification of Reliable Process	3
I knew that this was a Man vs. Nature conflict because the parts of this conflict matched this kind of conflict.			4
	OK, that still doesn't make sense to me, but then she says …		5
The fact that Esperanza's papa died is natural. It just happened. That part of it is "Nature."			6
	…so she does give an explanation,	Epistemic Ideal	7
	so, I'll read through just to see if there's something I can go back to. So [reading]	**Justification of Reliable Process**	8

Fig. 4. Justification of reliable process.

Again, Mr. Sparrow shifted focus from this specific student to a consideration of the class and the curriculum expectations for them. At this point in the data it is unclear whether the consideration of this tangential piece of knowledge was part of a larger cycle of epistemic cognition for Mr. Sparrow (or his students) or not. We targeted this statement in our analysis because he considered an epistemic matter and the nature of the fifth grade literacy curriculum. However whether this led to a specific epistemic end was undetermined. This shifting from class-focused to learner-focused cycles of epistemic cognition was also seen in our discussion of Ms. Cooper's interpretation of her student's use of quotations. In her comments she shifted from the individual student's use of quotations, to what is typical of the curriculum for this grade. Thus, this shifting of cycles emerged across teachers, and is further illustrated in the next sections of our microanalysis.

Justification of reliable process. The next segment of the think-aloud, Fig. 4, illuminates a possible new topic for consideration in models of epistemic cognition; the justification of reliable processes as a justification of procedural knowledge.

First, Mr. Sparrow described a second reliable process for constructing understanding of student work at the class-focused cycle while addressing the task of his own teaching practice. The reliable process he described was to read the entire entry before commenting. Many teachers (and college professors) may see this as an "obvious" rule of practice, however, for Mr. Sparrow this was an intentional process he engaged when reviewing student work for a specific purpose, to prevent himself from providing feedback too soon. Second, he justified the use of this reliable process by referencing Anna's work as an example. Shifting back to the learner-focused cycle he read her sentence stating what the conflict of the story was (Fig. 4, row 2) and then stated that, at that point in the paper, he would be inclined to comment or ask for an explanation of this claim. Instead, he recognized that in a few more sentences she seemed to give an explanation; which justified his use of this reliable process for this learner-focused task (Fig. 4, row 3). Mr. Sparrow justified this process again, explaining that he read through the entire paper to see if there was something he needed to go back to and address (Fig. 4, row 8). This second justification was categorized at the class-focused cycle of epistemic cognition, because even though his thinking processes were contextualized to Anna's work, he explained and justified the overall approach (reliable processes) that he employed with all of these papers.

Specifying aims for learners with teacher's epistemic ideal(s). Two important processes are evident in Fig. 5; Mr. Sparrow identified a source for his personal knowledge construction (rows 1–4) and used his epistemic ideals to develop specific aims for Anna (rows 5–7). Fig. 5, Row 1 depicts Anna's description of conflict in her story. After reading this section, Mr. Sparrow stated "Alright, so that tells me a lot right there" (Sparrow_TA_12/3_RR), which showed his identification of a knowledge source that could be used to achieve his epistemic aim of "… looking for her understanding of conflict" (Sparrow_TA_12/3_RR; Fig. 3, row 4). This segment of her writing was a central source of information from which Mr. Sparrow constructed his understanding of Anna's understanding of conflict. In Fig. 5, row 4, Mr. Sparrow described his next steps for working with Anna: to confer with her the next day and talk about a particular part of her text. It is worth noting here that while epistemically informed praxis is an outcome of epistemic cognition, Mr. Sparrow made an in-progress epistemically informed praxis decision before articulating his ideals. This may be due to the limitations of data collection, such that Mr. Sparrow was thinking faster than he could talk. Additionally, this entire process, in real time, occurred within a matter of minutes, and was a routine he conducted regularly. Thus for Mr. Sparrow, the comparison of Anna's work to his epistemic ideals may have seemed obvious to him given his expertise.

In rows 5–7 of Fig. 5, Mr. Sparrow described his reasoning for his in-progress epistemically informed praxis decision, using his epistemic ideals to guide the specification of aims for Anna. Mr. Sparrow described two epistemic ideals about the nature of conflict in narrative writing: (a) the conflict does not change (row 5) and (b) conflict is what the character struggles with (row 7). Mr. Sparrow's comparison of Anna's work to his epistemic ideals regarding conflict, allowed him to develop specific epistemic aims for Anna. Recall, in Fig. 3, Mr. Sparrow's epistemic aim was for students to understand the nature of conflict. After reviewing Anna's paper and targeting the segment of her writing that provided Mr. Sparrow with insight into her thinking (rows 1–3), he developed more specific aims about the nature of conflict that

Specifying aims for learner with teachers' epistemic ideals

Teacher reading student work	Teacher reflective self-talk	Analysis Class-focused Cycle Learner-focused Cycle	Row
Therefore, this conflict is a Man vs. Nature conflict. Later though, the conflict becomes Man vs. Man, because then, Tio Luis, Esperanza's uncle, does bad things to Esperanza and her mama and he becomes their problem, but the fact that Papa dies started everything.			1
	Alright, so that tells me a lot right there. So that tells me she has, towards the end, this is the idea to focus on, so this part from right here,	Identification of Knowledge Source	2
She is the protagonist. Therefore, this conflict is a Man vs. Nature... Later though, this conflict becomes Man vs. Man.			3
	So this tells me, and this is where she and I are definitely going to confer tomorrow to talk about this particular part,	In-progress Epistemically Informed Praxis	4
	because what I want her to know [places asterisk next to "Later though" and brackets the entire sentence[1]] is that your conflict and the conflict type isn't necessarily going to change. …	Epistemic Ideal Specified Epistemic Aim for this Learner	5
	… but there's two things that I definitely want to go over with Anna. One is that "The conflict is that Esperanza's papa dies" [referring to student's work].	Specified Epistemic Aim for this Learner	6
	Well, a conflict is what the character is struggling to get, what the character's struggling for, or what the character's struggling against. So her papa dying isn't necessarily the conflict, it's what she struggles for because of that…	Epistemic Ideal	7

[1]See figure 1

Fig. 5. Specifying aims for learner with teachers' epistemic ideals.

Anna needed to achieve, and these mapped onto the epistemic ideals he articulated.

Continued epistemic cognition at class cycle; epistemic end at learner cycle. In this last excerpt, Fig. 6, Mr. Sparrow re-engaged his class-focused cycle of epistemic cognition before shifting back to the learner-focused cycle and coming to a final end of epistemically informed praxis.

In the first row of Fig. 6, Mr. Sparrow stated an in-progress epistemic end for himself (i.e., an epistemic stance); his developing understanding of what the whole class was struggling with in terms of conflict. Recall that just prior to this revelation he specified new aims for Anna, using the information from this one student, he then shifted to class-focused epistemic cognition related to his developing understanding of the needs of his entire class. Then in row 2 of Fig. 6, he provided further justification for his epistemic ideals about the nature of conflict by drawing a parallel between Anna's book (*Esperanza Rising;* Muñoz Ryan, 2000) and the book, *Because of Winn Dixie*, (DiCamillo, 2000) that the whole class was reading. In these rows, Mr. Sparrow's comments highlighted the shifting nature of epistemic cognition in teaching practice and the need for teachers to consider and integrate multiple domains of knowledge. In trying to develop an understanding about his students' growing conceptions of conflict, Mr. Sparrow formed a tentative or in-progress end (i.e., "I think that's what the students are having trouble with"), but then reached back to his personal understanding of the content and used a second text to further justify the epistemic ideals he used to evaluate student work.

Mr. Sparrow quickly returned to examining Anna's work, where he made another in-progress epistemically informed praxis decision (Fig. 6, row 3). He identified a phrase in Anna's writing that he wanted to conference with her about because it did not meet his epistemic ideal for conflict that he justified in the row above.

Mr. Sparrow then shifted knowledge domains to general pedagogy in row 5 where he provided a justification for his practice of *not* writing extensive feedback to Anna regarding the two specified aims he intended to address (conflict does not change; conflict is struggle). He explained that a longer note here might be misinterpreted by Anna and as such could lead to further misconceptions rather than helping her to achieve the epistemic aim of understanding conflict. This justification of practice illustrated again the multi-domain nature of teachers' epistemic cognition. That is, Mr. Sparrow first had to understand Anna's work for himself, then using content-focused ideals he determined the areas for further work. He put those understandings into practice when

Continued epistemic cognition at class cycle; epistemic end

Teacher reading student work	Teacher reflective self-talk	Analysis **Class-focused Cycle** Learner-focused Cycle	Row
	And that's what I think the students are having trouble with-	**In-progress Epistemic End for Self** (Understanding of Students' Knowledge of Conflict)	1
	with *Because of Winn Dixie* is it that her- Opal's mom left, or is it that Opal has to figure out a way to cope with her mom leaving? So I don't think the struggle's necessarily- she's not struggling against her mom being gone, that's something that gives her a problem, she's struggling to cope with that, so one led into the next. So it's kind of, so it built into that.	**Justification of Knowledge**	2
	I want to go over this line, so I'll put a bracket around it,	In-progress Epistemically Informed Praxis	3
[The conflict is that Esperanza's papa dies.]			4
	And then because there's a lot I want to say about that with Anna, what I'll do is I'll write "See me, review this" If it's something quick I can go over, I'll write that quick note in here, but she can see that just in the same way people can misinterpret an email or something like that. I want to make sure that we go over it together, and we make a conference out of it, because if I write a note, she might misinterpret that, and I want to make sure that she and I definitely go over that.	Justification of Practice	5
	…So actually what I'll do is I'll put an asterisk there and I'll just say, [puts asterisks on two points bracketed points and writes[1]] "Let's review these two ideas."	Epistemically Informed Praxis	6

[1]See figure 2

Fig. 6. Continued epistemic cognition at class cycle; epistemic end.

he considered the pedagogical and communication issues regarding providing feedback to fifth grade students. He determined that the specified aims were too important (possibly an epistemic value) to risk having Anna misinterpret the note. Thus, his final decision, ending this learner-focused cycle of epistemic cognition was the epistemically informed praxis of placing asterisks beside the two points in Anna's writing and leaving her a note that they would talk about those two points (Fig. 6, row 6).

9. Discussion

The goal of this instrumental case study was to offer examples of how teachers enacted the components of epistemic cognition as well as examples of how epistemic cognition unfolded in situ as teachers interpreted student work. From our analysis we forward four points for discussion. First, we offer empirical evidence to support the theoretical claim that teachers engage in epistemic cognition during some classroom assessment tasks. Second, we provide evidence for the claim that such tasks necessitate the management and use of multiple knowledge domains. Third, an examination of teachers' epistemic cognition in situ revealed that cycles of epistemic cognition can include multiple in-progress epistemic ends along the path to achieving immediate and ongoing epistemic aims. Fourth, when engaged in interpreting student work, teachers employed both epistemic and non-epistemic aims, ideals, and processes.

9.1. Empirical evidence for epistemic cognition in classroom assessment

Recall that in this study, teachers were not prompted or asked to comment on their epistemic cognition. Instead, these processes were captured as a result of observing teachers interpret student work and plan for instruction. This provides initial evidence that epistemic cognition is an inherent process involved in some classroom assessment tasks. Across all teachers, we saw multiple instances in which teachers set aims for themselves and for their students. Similarly, all teachers used a variety of reliable processes to achieve epistemic aims or to evaluate epistemic matters in relation to existing epistemic ideals. Thus, this study offers empirical support for a framework of epistemic cognition that was primarily theoretical in nature (Buehl & Fives, 2016; Fives et al., 2017), and describes the nature of epistemic cognition employed for teaching.

Of note for researchers interested in exploring teachers' epistemic cognition, we found that teachers were more likely to externalize some components of epistemic cognition more so than others. Specifically, we

saw teachers reference ideals and reliable processes, and were less likely to spontaneously talk about their aims or ends. For researchers to continue to parse and delineate the components espoused in the theoretical frameworks proposed by Buehl and Fives (2016) and Fives et al. (2017), we will need additional evidence related to all the components, and therefore targeted methods to externalize those that are more likely to remain hidden.

9.2. Managing multiple knowledge domains

Teachers' epistemic cognition during assessment-related activities necessitated the management and use of multiple knowledge domains. While typical investigations of learners' epistemic cognition have focused on singular topics (e.g., climate change) within an academic content area (e.g., science) the knowledge required for teaching spans multiple domains and fields of study and includes teachers' developing knowledge of situated practice (e.g., craft knowledge: Grimmett & MacKinnon, 1992; milieu of teaching: Elbaz, 1987).

We saw evidence that teachers had epistemic aims for self, such as wanting to understand their students' comprehension skills, but that these aims often required the management of multiple domains of knowledge. This included knowledge of content, assessment practices, students, child development, context, and curriculum. This was particularly evident in the microanalysis of Mr. Sparrow, where we observed him seeking to understand a student's progress (knowledge of student), but also considering the text she wrote about (knowledge of content), the reading strategies expected (knowledge of curriculum), and his own processes for interpreting or assigning meaning to the student's work (knowledge of pedagogy). To do this, he drew on knowledge of this particular student, the curriculum, the text, child development, and pedagogy to make informed decisions about what to assess and how to assess it. Recall that in this study epistemic cognition was situated within the domain of teaching and the task of interpreting student work. Had the domain and task differed (e.g., instruction, lesson planning, designing assignments), we may have observed other epistemic processes.

We also saw evidence of teachers managing multiple domains of knowledge when they set epistemic aims for their learners. For example, recall that Ms. Lang decided to change the word bank in a vocabulary assignment for her ELL so that her interpretation of students' performance on the assignment would better represent their actual skills. This decision resulted from her understanding sound assessment practices, the needs of her students, and the curriculum. Moreover, as teachers interpreted student work they used and built their personal knowledge to support practice. Grimmett and MacKinnon (1992) defined craft knowledge as "the construction of situated, learner-focused, procedural and content related pedagogical knowledge through 'deliberate action'" (p. 393). As teachers in our study grappled with student work we saw instances of their development of this kind of situated knowledge that illustrated an integration of multiple forms of knowledge; which may suggest yet another cycle of epistemic cognition that is self- or teacher-focused for the task of teaching. This was evident when Mr. Sparrow provided a justification for his teaching practice (see Fig. 4, row 4) and later when he justified his use of a particular reliable process (see Fig. 5, rows 1–3). Each instance of interaction and reflection on his work provided Mr. Sparrow with an opportunity to hone his craft knowledge for practice in his context and doing so required the integration of multiple knowledge domains.

If we shifted the focus of this study from the interpretation vertex of the assessment triangle to either the cognition (identifying knowledge and skills to assess) or observation (identifying/constructing tasks to invoke targeted knowledge skills) then we expect teachers would similarly need to engage in epistemic cognition within both vertices and while doing so utilize multiple knowledge domains. In the cognition vertex teachers need to determine what to assess in specific contexts (Pellegrino, 2014). Such determinations should require teachers to consider the nature of knowledge they intend for students to develop as well as the processes by which such knowledge is constructed; thus, these determinations should require epistemic cognition. Further, to make these determinations teachers may evoke ideals related to cognition and learning that they temper by other knowledge domains such as students, curriculum, and subject area. In the same way, the selection/development of assignments in the observation vertex should rely on teachers' explicit consideration of what evidence might be needed to make interpretations about students' knowledge, an epistemic task. These are areas that require further research, in particular there is a need to see how theoretical frames of the assessment triangle and teachers' epistemic cognition can be used in concert to facilitate teachers' initial and ongoing professional learning.

9.3. Shifting cycles of epistemic cognition: an issue of grain size

Teachers' epistemic cognition appeared to be enacted as a series of interactive cycles that attended to epistemic aims targeted at different levels of complexity, varied tasks, and for differing groups of practice (e.g., self, individual learners, class). Alexander (2017) highlighted this perspective on teachers' epistemic cognition as an issue of "grain size" (p. 310). We see this issue of grain size as one of recognizing the cycle or cycles of epistemic cognition that foreground our study. Our microanalysis of Mr. Sparrow illustrated iterative micro-cycles of epistemic cognition leading to in-progress epistemic ends before his learner-focused aim was achieved leading to epistemic praxis which informed his class-focused cycle. At the same time, Mr. Sparrow shifted among cycles of epistemic cognition related to a single student, to the class, to the overall curriculum, and to his own learning. While the micro-analysis of Mr. Sparrow provides the best illustration of these shifting cycles there is evidence of this practice embedded in the other examples provided. For instance, Ms. Lang described shifting from individual to whole class performance on vocabulary tests.

In order to highlight the complexity of the shifting cycles of epistemic cognition we offer Fig. 7 as one way to illustrate this phenomenon. In this illustration we see each cycle as an ongoing process initiated by different epistemic aims at different points in time for the individual. Further, the illustration is meant to signal that cycles of epistemic cognition occur across varied time spans and may interact or cross paths with each other when individuals engage with specific tasks - such as interpreting student work. We use the information from our microanalysis of Mr. Sparrow to make this illustration concrete. In box 1 of Fig. 7 we offer Mr. Sparrow's class-focused cycle where his aim during the task of interpreting students' reading responses was to understand students' understanding of conflict in literature. This cycle has an arrow at the end suggesting that it continues on, as Mr. Sparrow continues to engage with his students he will continue to build his knowledge of their capabilities over the course of his time with them. As Mr. Sparrow began to evaluate individual student work, he established an aim of understanding one particular student's (i.e., Anna's) understanding of conflict, and thus a learner-focused cycle was initiated as an offshoot of the class-focused cycle (box 2). The class-focused and learner-focused cycles intersect in box 2 to show that during the task of interpreting student work Mr. Sparrow was constructing knowledge about both his class as a whole and Anna in particular. Further, this intersection also indicates the interaction between these two cycles such that the information Mr. Sparrow learned about this particular student in the learner-cycle informed his understanding of students' understanding of conflict in the class cycle. One could further imagine similar learner off shoot cycles for each student in his class as he continued to review students' work.

Boxes three and four depict larger grain size cycles of epistemic cognition (i.e., Mr. Sparrow's own understanding of the content, and his teaching wisdom) that were likely initiated well before this particular episode, but were re-engaged as part of his analysis of student work, and modified as a result of this process. In box 3, we illustrate the

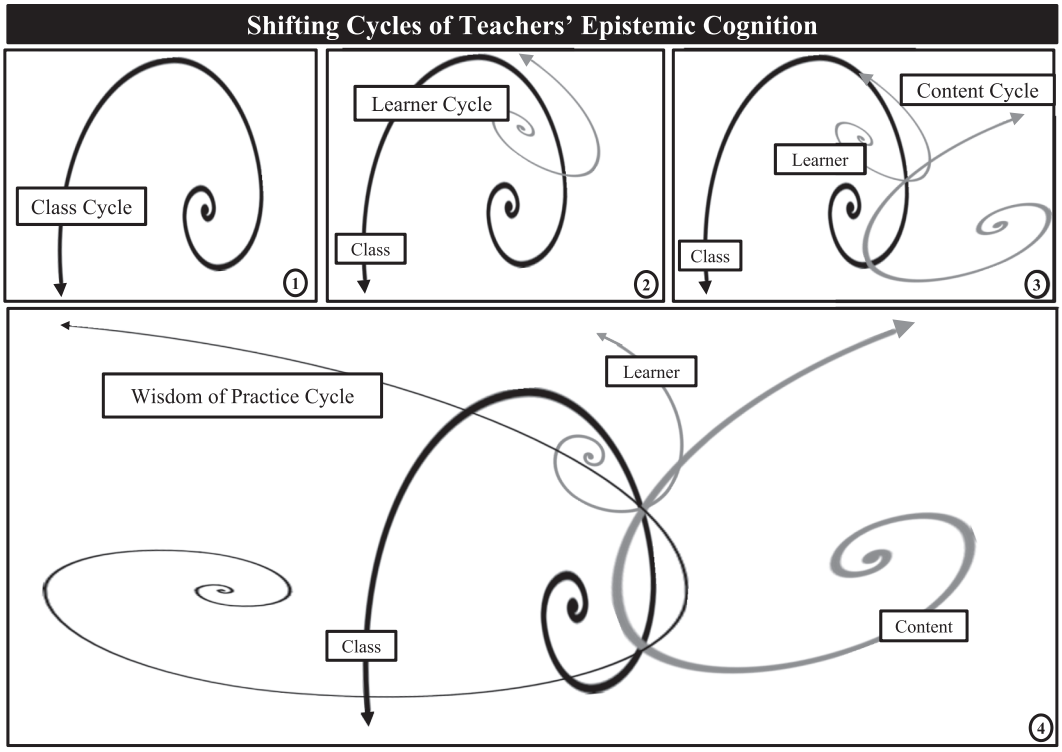

Fig. 7. Shifting cycles of teachers' epistemic cognition.

content cycle, that is Mr. Sparrow's contemplation and evaluation of the subject matter, in our data this included both an understanding of literary devices (e.g., conflict) as well as knowledge of the literature students read. In box 4, we added the wisdom of practice cycle to illustrate Mr. Sparrow's ongoing knowledge construction for the practice of teaching as well as his justification of his work. This final image illustrates the intersection of the cycles that occurred during the task of evaluating student work, but also indicates other hypothetical moments/tasks where these cycles intersected in the past or will do so in the future. While we anticipate that some of these cycles may come to an end, such as those for individual students, we placed an arrow at the end of the cycles to indicate that teachers' epistemic cognition for their practice is an ongoing process.

That teachers engaged in epistemic cognition across varied cycles was not particularly surprising, in fact Ruiz-Primo et al. (2012) asserted that assessment events vary along a continuum including immediate, close, proximal, distal, and remote. Each of these levels of assessment require epistemic cognition at varied grain sizes. What was surprising in our analysis of these data was that even when engaged in an immediate task of interpreting student work, teachers shifted the focus (student, class, self) and scope (target strategy, overall curriculum) of their epistemic cognition. How these cycles of epistemic cognition interact and inform each other could illuminate our understanding of teachers' decision making, assessment practices, and ongoing professional learning, and have implications for the Buehl and Fives (2016) and Fives et al. (2017) frameworks. Such frameworks may need reorganization to capture the dynamic nature of the cycles as part of teachers' epistemic processes.

9.4. Epistemic and non-epistemic aims, ideals, and processes

Throughout our investigation we saw teachers identify aims, the means to achieve those aims, processes, evaluate the outcomes of those processes with ideals, and come to decisions about knowledge and practice. In this study, we focused on teachers' epistemic cognition while interpreting student work. Recall, that the elements of the assessment triangle can be examined alone or in relation to how they work in tandem or tension with each other. Therefore, future research should explore teachers' epistemic processes in the cognition and observation vertices as well as the ways in which teachers enact epistemic processes within and across all the elements of the assessment triangle.

In this study, we expected that when teachers engaged in interpreting student work, a representation of learners' knowledge, that they would engage in epistemic cognition. What we found, however, was that this was not always the case. While we saw instances where teachers articulated explicit epistemic aims, engaged reliable processes, and yielded epistemic ends, we also saw instances where non-epistemic aims were forwarded and used to achieve non-epistemic ends. A challenging aspect to our data analysis was assigning meaning to aims the teachers articulated, as noted by Alexander (2017):

> …there is limited sense of what facets of classroom instruction fall neatly within epistemic and non-epistemic categories. There is also little understanding of the way in which epistemic and non-epistemic goals or actions might complement or conflict within the flow of instruction (p. 310).

For instance, we described Ms. Lang's practice of color coding her gradebook as an example of a process for achieving a non-epistemic aim of organization. However, as we noted, this process of organization may well have supported an epistemic aim for Ms. Lang at some point as she interpreted scores in her gradebook; indicating one way that epistemic and non-epistemic aims may complement each other in the classroom environment.

Non-epistemic aims are certainly important to the overall teaching enterprise. Of concern, are instances where non-epistemic aims conflict or even inhibit epistemic processes. In the example of Ms. Jones, who just wanted to get through her interpretation of student work quickly, epistemic cognition was inhibited. Thus, learning about student progress may not have occurred. Further exploration into teachers' epistemic practices including the interactions between teachers' epistemic

and non-epistemic processes are needed to fully understand how teachers' epistemic practices can lead to optimal learning experiences for students.

In addition, future work should consider the ways that teachers select and justify the epistemic reliable processes they use themselves or require of their students. While we saw evidence of Mr. Sparrow justifying his re-reading reliable process, there was little evidence in our data of teachers' justification of the reliable processes they expected students to use. For instance, Ms. Walsh required her students to color code their writing revisions; which we inferred as a reliable process to reach the broad aim of developing good writing skills and habits. However, our investigation did not explore the extent to which this process actually helped students achieve this aim or not; nor did Ms. Walsh provide justification for the use of this process. It is unclear if this is a technique she developed herself, learned from a colleague, or found in professional literature with an evidence base to support its use. When teachers establish reliable processes for students to achieve epistemic ends there may well be a need to evaluate the source of those processes and the evidence that endorses their use (or does not).

Moreover, data from our microanalyses suggested that some episodes of epistemic cognition were more effective than others. For example, Mr. Sparrow selected reliable processes that aligned with his aim, were reflective of his ideals, and led to informed decisions. This may be what Barzilai and Chinn (2018) described as *apt epistemic performance*, or the ability to "reliably succeed, through competence, in epistemic activities such as forming accurate judgments or evaluating arguments, across a range of situations" (Barzilai & Chinn, 2018, p. 362). Further exploration into teachers' epistemic practices including the interactions between teachers' epistemic and non-epistemic processes as well as the identification of the qualities that may represent apt epistemic performance, are needed to fully understand how teachers' epistemic practices can lead to optimal learning experiences for students.

10. Limitations

This was a small qualitative study that included a population of White teachers in relatively affluent schools. As such these results are not generalizable or predictive of the practice of other teachers or in other contexts. Instead, we offer what Stake (1978) referred to as "naturalistic generalizability," which allows for the findings from one study to be used as exemplars/models for understanding phenomena and can serve as a guide to other researchers' work. We also used data gathered for another purpose, thus we did not ask targeted questions related to epistemic cognition. On the other hand, because we were not trying to elicit teachers to engage in epistemic cognition, our results present a more naturalistic illustration of how these practices unfold.

11. Conclusion

This work is significant for scholarship and practice related to teachers' epistemic cognition. This is one of the first qualitative investigations of teachers' epistemic cognition using the new models forwarded by Chinn et al. (2014), Greene et al. (2008, 2010), and Fives et al. (2017). From a theoretical perspective this work supports these new models and further problematizes what this process looks like for teachers engaged in multiple cycles of epistemic cognition when they interpret student work. The findings also highlight the challenges that teachers face as they weigh their own knowledge of the domain/content (ideals) with the representations that students provide in order to make decisions about future instructional actions (praxis). It may be that teachers need to activate their existing epistemic ideals and remind themselves of the aims they have for themselves and their students to engage in productive epistemic cognition. We see this investigation as an embarkation point for more descriptive, quantitative, and intervention research that can forward thinking and praxis.

12. Author note

The first two authors contributed equally to this manuscript; they rotate order of authorship in their scholarship. The second two authors contributed equally to this manuscript working in close collaboration.

Appendix A. Data use think-aloud interview protocol

Orientation to Think-Aloud Interview

Hello, thanks once again for agreeing to participate. As you know the goal of this study is to identify the overall process you engage in and the specific, microprocesses you use to convert student responses into information that informs your practice.

During the next two weeks we will be working with you to develop an understanding of your thinking and reasoning around using classroom level data to inform your teaching practice.

We have scheduled these times to coincide with when you are typically interacting with students' classroom performance data and/or planning for instruction.

Instructions/Reminders

During these sessions, I am going to ask you to engage in your work as you would normally, and that you think aloud while doing so. The goal is for you to make your inner voice audible to me.

- Don't try to plan what to say or speak after the thought, but rather, let your thoughts speak, as though you were really thinking aloud.
- In order to understand your thinking processes, especially in the beginning of the session, it would be helpful if you could explain each step of what you are doing.

I will try to refrain from interrupting your flow, but may remind you to talk aloud, or upon occasion ask for further explanation of a decision or process I observe.

While engaging in this interview, I will take notes of what you are saying and make copies of materials you use (with your permission and with any student information removed). But I will rely primarily on the audio recording of your think-aloud process.

As you discuss the assessment data you may want to talk about a particular student or refer to his/her work. If that occurs, please do NOT say the student's name, and use one of these post-it notes to cover any identifying information. I am interested in the meaning you make from the student data, not the students.

Please remember that I am not here to evaluate or critique you, but to understand your process. The more you can talk about that process the more helpful it will be for my research. If you need or want a break just let me know.

Do you have any questions?

< < < < respond to appropriate questions > > > >

Let's get started.

Closing

Thank you once again for your time and willingness to share your work with us. While we have scheduled these interviews to coincide with your schedule we realize that you may engage in some planning or assessment related activities when we are not present. Thus, we are lending you this audio recorder and we ask that, should you do any planning or assessment activities when we are not present, that you continue to think-aloud during this time and to record your process for us.

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