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Margaret A. Macintyre Latta
University of Nebraska-Lincoln, Margaret.Macintyre.Latta@ubc.ca

Gayle Buck
University of Nebraska - Lincoln

Diandra Leslie-Pelecky
University of Nebraska-Lincoln, dleslie-pelecky1@unl.edu

Lora Carpenter
University of Nebraska - Lincoln

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Margaret Macintyre Latta*, Gayle Buck,
Diandra Leslie-Pelecky, and Lora Carpenter

University of Nebraska–Lincoln, USA

*Corresponding author. College of Education and Human Sciences, 118 Henzlik Hall, University of Nebraska–Lincoln, Lincoln, Nebraska, USA. Email: mlatta2@unl.edu

Abstract: Teaching and learning continues to be driven by a version of professionalism that construes practice to be a form of applied science. This paper challenges that paradigm. In particular, subjecting and assimilating practical activity to a technical mode of rationality is challenged as not being the most appropriate way to approach teaching, learning, and the process that drives both of these phenomena, inquiry. Middle school science classrooms provide the contexts to explore the situated consequences of embracing the terms of inquiry. Placing inquiry at the core of the thinking and experiences of middle school science educators as a philosophical/theoretical/practical educative process to be worked with, and concomitantly, working as dynamic practice, yields working notions to be necessarily embedded, cultivating, sustaining, and nurturing inquiry in teachers' practices. As teachers experimented directly with the working notions of seeing, relational knowing, mindful embodiment, and assessment as interrelated and interdependent with inquiry, the teaching/learning outcomes authorized more and more inquiry in teachers'—and then students'—practices. An operative and active professional model emerges out of these working notions with the lived terms of inquiry identified as participatory in nature, vigilant to the question(s) in which the inquiry originates, organic in form, and always turning back on self, as catalysts in support of inquiry.

Keywords: Assessment, Embodiment, Inquiry, Professional development, Science education

Introduction

> It was not so much science this year. It was called science. But the teacher just read, we reviewed, and then there would be a quiz. That is not science to me. Science is building, experimenting, testing—like when I built a hot air balloon ... I took it out to Pioneer Park but it was too windy. I brought it back to my garage and tried it out there. I like finding things out for myself. (Personal interview, Will, 14 June 2001)

These are the words of Will, a Grade 6 student. Nearly 100 years ago Dewey presaged Will's thinking, stating:

> Science has been taught too much as an accumulation of ready-made material with which students are to be made familiar, not enough as a method of thinking, an attitude of mind, after the pattern of which mental habits are to be transformed. (Dewey, 1964, p. 183, first published 1910)

Will's, Dewey's, and our primary contention is that the terms of inquiry are too often betrayed not only within the study of science, but in all teaching and learning. And clearly this is not a new contention. Dewey (1964) harkens back to Herbert Spencer's (1860) question, "What knowledge is of most worth?" as the *crux* of betrayal. Dewey (1964) speaks of a knowledge that:

> never can be learned by itself; it is not information, but a mode of intelligent practice, a habitual disposition of mind. Only by taking a hand in the making of knowledge, by transferring guess and opinion into the belief authorized by inquiry, does one ever get a knowledge of the method of knowing. Because participation in the making of knowledge has been scant, because reliance on the efficacy of acquaintance with certain kinds of facts has been current, science has not accomplished in education what was predicted for it. (Dewey, 1964, p. 188)

Dewey outlines how authorized inquiry orients knowledge-making toward building relationships between self, others, and subject matter through participatory thinking. If the act of building connectiveness between self, others, and subject matter is the necessary learning thread promoting meaningful inquiry, it is imperative that educators better understand its nature and implications.

Recent teacher education research (see Dunne, 1993; Kessels & Korthagen, 1996; Korthagen & Kessels, 1999; Carr, 2000; Davis *et al.,* 2000; Cochran-Smith, 2001; Gallego *et al.,* 2001; Korthagen, 2001; Sidorkin, 2002; Jardine *et al.,* 2003) reiterates Dewey's (1904, 1964) thinking, establishing the complexity of inquiry. Neglected in these current studies are the conditions that enable inquiry practices in teachers and support the potential for learners and learning. As science educators, in particular, encounter the call for science instruction within an inquiry framework (NRC, 2000), studies that examine the nature of inquiry are critical. The need for a professional development initiative that addresses these aims is a well documented need in the science education research literature (see Crawford, 2000; Supovitz & Turner, 2000; Keys & Bryan, 2001; Luft, 2001) and also the general education research literature (see NCTAF, 1996; Fullan, 1998, 2000; Darling-Hammond & Sykes, 1999; NERPPB, 1999; NRC, 1999, 2000; Schoenfeld, 1999; Zeichner, 1999; Cochran-Smith, 2001; Korthagen, 2001; NSDC, 2001; US Depamnent of Education, 2002). Acting on Dewey's (1910; see Dewey, 1964) thinking we embark on a study intended to authorize greater inquiry with participating middle school science teachers orienting knowledge making toward building relations between teachers, students and subject matter.

Accounting for inquiry

We contend that much of teaching and learning today continues to be driven by a version of professionalism that construes practice to be a form of applied science. Un-

der such a model, knowledge is separated into two distinct entities: abstract theory and technological know-how. Neither of these types of knowledge provides an adequate basis for teachers to make moment-by-moment, value-laden decisions encompassing competing demands for immediate action. Neither of them takes into account that practical activity is not based solely on theory and/or technique, but occurs alongside teachers' understandings of the learning situations they face. Our study examines teachers' roles in facilitating science learning, seeking out what is necessary for teaching, leaming, and the process that drives both ofthese phenomena, inquiry.

Boisvert (1998) refers to the "Deweyan outlook" as "admit[ting] the active and operative character of inquiry" (p. 38). It strikes us that integrity to this process character is indeed a given as we seek out the terms of inquiry alongside all participants. Thus, our ensuing inquiry is very much inquiry guided and the account created "admits" such attention to process. Positioning teachers to come to terms with the lived consequences of inquiry in their classrooms entails creating situations that occasion inquiry through purposefully designed content and inquiry focus group workshops, ongoing classroom observations, and reflective interviews. We relay some of these situations occasioning inquiry, in an effort to engage readers in the ongoing reflexivity experienced by all participants. A capacity to see and attend to student learning through relational knowing, mindful embodiment, and assessment as inquiry, surface as working notions participating teachers discover and negotiate within their practices. Authorizing more and more inquiry is the result, as the working notions come to be better understood within the lived realities of classrooms. Realized through ongoing teacher discovery and experimentation with the working notions, we identify interrelated and interdependent lived terms of inquiry to be participatory in nature, vigilant to the question(s), organic in form, and always turning back on self. It is through attending to this process character that we invite the reader to participate, taking up inquiry through inquiry itself. And it is our intention that the reader is able to trace the origins and development of these terms in the ensuing account and concomitantly experience these terms firsthand as inquiring readers.

Partners in inquiry

Our study provides opportunities for teachers and students to experience learning connectiveness, deliberately positioning teachers and students to see and articulate the significances of inquiry for science teaching and learning. This study involves six volunteer middle school science teachers committed to creating learning encounters foregrounding scientific inquiry, connecting thinking processes and learning products/artifacts, and articulating teacher/student thinking throughout. The teacher's role in fostering this movement of thinking in students is examined alongside the significances for learners, learning, teachers, and teaching. The development and role that attention to thinking processes within inquiry might play in encouraging teachers to see, foster, and sustain teachingilearning encounters that promote scientific leaming connections and growth for all students is undertaken. Researchers

work alongside teachers as partners in search of the lived terms of inquiry given the concrete realities of each classroom.

A fitting way to proceed: case study

A case study approach (Creswell, 2002) at two levels is employed. First, in order to gain some understanding of each participating educators' experiences of inquiry in their classrooms, the researchers gather and analyze data from each site. All sites are inquiring into the same science curricular topic with participants' involvement extending over the nine-week duration of the unit of curricular study. Each participating teacher and classroom constitutes a case for analysis. Second, in order to discern the terms of inquiry, a cross case and group analysis is conducted. A reflexive approach (Alvesson & Skoldberg, 2000) to data collection and analysis is considered essential, operating both inductively and deductively throughout, providing means to address the interface between the empirical data collected (through ongoing content analyses of student/teacher artifacts, classroom observations, interviews, and focus group workshops), its interpretations, and the research literature. Dialogue is the fundamental means utilized to initiate and extend understandings of inquiry prompted through teacher and researcher reflective statements, sharing of researcher field notes, teacher lesson plans, and associated resources, and audiotaped interviews and focus group workshops, in a continuous responsive interchange. Data analysis takes place in three phases. Phase 1 focuses on the individual cases, responsive to the emergent features of each setting, blocking and labeling thematically all data, to ascertain similarities and differences for learners, learning, teachers, and teaching. Phase 2 entails a cross-case analysis identifying themes common to all cases and also significant differences among cases. Phase 3 entails a group analysis of data focused on finding an organizing kamework for ongoing professional development.

Occasioning inquiry

Creating situations that occasion inquiry, positioning teachers to rise to the needs of the situation, becomes the starting place. Content workshops, focusing on the curricular topic of electricity and magnetism, are facilitated by science, technology, engineering, and mathematics (STEM) personnel in a lab-like setting immersing participating teachers as inquirers seeking out new and expanded understandings of electricity and magnetism. An inquiry workshop that follows the content workshop immediately the next day provides an opportunity to reflect on the immersion experience.[1] Teachers comment that they left the content workshop "exhausted" yet also feeling "satisfied" (Focus group workshop, October 31, 2003). The immediacy and suddenness of this immersion in content through inquiry surfaces elemental responses that seem to have taken participants by surprise. Naming these responses elicits the significances of time to observe and linger with ideas, drawing on personal experiences and input from others, and feelings of vulnerability as a questioner and risk taker. The felt personal impact serves as both a reminder and a springboard to continually bring to bear alongside

the concrete practices of teaching for inquiry, confronting Dewey's and Will's understandings of matters of inquiry subsumed by matters of method thus predetermined, controlled, and certain. A diluted understanding of inquiry is generally acknowledged and the commitment taken up is to return inquiry to its original, serious, and difficult nature. Education as inquiry, after all, is concerned with "bringing forth" (educare) of human life, thus essentially a generative undertaking, concerned with emergence, the movement of thinking. Authorizing inquiry is precariously begun. The expanded content knowledge, greater familiarization with materials and equipment/tools, and associated terminology, prompts teachers to imagine how they could foster greater student inquiry in their classrooms. So, a confidence in the inquiry process and a confidence in content knowledge concomitantly reinforce each other, authorizing fragile understandings of inquiry in practice.

Both the elemental felt significances of inquiry in learning alongside the increased confidence in content begins to articulate theories that imply practices, and practices, teaching/learning ideas. To thicken these tentative findings regarding inquiry and begin to focus on teachers' roles in prompting inquiry, a video, *A case of drawing to learn* (Performanetics, 1991), is viewed in which a one-on-one mentor/learner relationship is depicted in an ongoing conversation focused on drawing a bicycle explicating how a bicycle works. The video vividly portrays a teacher's roles toward prompting inquiry in another. Theories implying practices, and practices ideas, take life in this video providing concrete images of inquiry in teaching/learning practices. It is a reminder that ideas need to germinate. As the learner's drawing begins to reveal what the learner did not know, the learner is assured that tentative, uncertain thinking is an important beginning. "We need to help children treat their partial knowledge as the best place to begin" (Forman, 1991). Increasingly the learner sees the drawing as a heuristic, a medium to learning. The drawing becomes a work in process, parts are reworked, crossed out, reconsidered, as the learner talks about his drawing of the bicycle with the mentor, realizing gaps in thinking, locating terms, and seeing his drawing in a new way. This cycle defines the process "drawing to learn." And, so, the drawing makes visible the student's inquiry as a conversation linking sense making. This conversation is guided skillfully by the mentor; generative—arising out of the subject matter and returning to the subject matter—reciprocal between learner, subject matter, and mentor, all enveloped in a conjoint, purposeful enterprise. The power of this visual imagery allows teachers to observe as outsiders and yet seem to be there, gaining access to the sensory lived aspects. The movement of authorized inquiry is glimpsed and viscerally understood as Dunne (1993) reiterates:

> It is in fact the source of the movement that we have all the time been glimpsing in understanding itself and which bas, moreover, all the time been making itself felt in our own attempt to understand it. (Dunne, 1993, p. 137)

As teachers prepare to return to their classrooms to embark on the electricity and magnetism unit of science study, the nature of planning is considered. The planning process enabling teaching/learning for greater science inquiry asks teachers to con-

sider the terms and conditions necessary to create science-learning situations that occasion inquiry in students, positioning them to be inquirers, creators of meaning. Thus planning necessarily needs to consider individual school contexts, and particulars of students, and benefits from other participating teachers providing shared insights, activities, resources, and expertise. As teachers assemble the curricular materials for their personal construction of a unit on electricity and magnetism they are asked to see these as materials to incite students to interact, dialogue, and traverse, retuning to the imagery of the video *A case of drawing to learn* (Performanetics, 1991) and the content and inquiry workshops as reference and reminder of inquiry in practice.

Each teacher returns to their classroom as practitioner-inquirers seeking out the lived terms of inquiry in their middle school classrooms. Haunted by Dewey's (1904) warning that theory does not necessarily follow into practice, researchers are cognizant of the important role of regular classroom observations and feedback in keeping inquiry in the foreground of teacher, and thus, student thinking. Over the nine-week curricular unit of study the researchers become accepted visitors in each of the participating educators' classrooms gaining familiarity with contexts and students. As teachers attempt to teach for greater student inquiry, the researchers offer affirmation and prompts, further authorizing teachers' beliefs in inquiry. Teachers' confidence in the inquiry process ranges dramatically from outright fear of the consequences for classroom management and learning tasks, to excitement at the prospect of accepting greater ambiguity, uncertainties, and practice exercising judgments within the inquiry process rather than complete reliance on predetermined rules and procedures. Researchers alongside teachers then enter into an ongoing interchange derived from seven-nine classroom observations of each case, artifacts collected from teachers such as lesson plans, assessment rubrics, and assignment outlines, student artifacts documenting learning, as well as two audiotaped individual teacher/researcher interviews and two audiotaped focus group interviews with all participating teachers and researchers. Classroom observations are always followed by an email conversation with the researcher and teacher critically looking together for the consequences of teaching/learning for inquiry, or, away from inquiry. And, indeed, it is in the questioning of moments within learning by teachers, by the researchers, that the lived conjuncture of theory/practice for greater inquiry comes alive and strengthens convictions. The workshop experiences with theory and theorizing, imagery, first-hand inquiry, and content knowledge, all serve a reflexive role as ideas are rediscovered by teachers within the concrete realities of the science classroom. And, these moments of catching self in the act of inquiry strengthen and authorize inquiry with greater and greater paradoxical audacity and tentativeness. Audacity refers to belief placed in the value of entering into inquiry. Belief takes up purpose as something to be worked towards, rather than something that is necessarily present at the beginning. Tentativeness refers to the exposed, uncertain movement such participation demands. Commitment is required to engage in the grappling and questioning required for the pursuit of meaning. Negotiating between audacity and tentativeness embraces these contraries as an interacting and interconnecting relationship, way-making in a constant interchange between self and situation. Authorized in-

quiry needs to strengthen through lived sensations; its life taking form through participating teachers' deepening understandings.

Yielding working notions

Placing inquiry at the core of the thinking and experiences of six middle school science educators (over one curricular unit of science study extending over nine weeks) as a philosophical/theoretical/practical educative process to be worked with yields working notions to be necessarily embedded, cultivating, sustaining, and nurturing inquiry in teachers' practices. Boisvert's (1998) explication of inquiry as "active and operative," undermining any single, privileged perspective, affirming the importance of experimentation, and emphasizing continual growth in awareness, is revealed (p. 38). Inquiry in motion surfaces the following four notions at work in the curricular lives of teachers.

Seeing

The Latin root of inquiry is "to seek." Inquiry requires a seeker "seeing" from within situations. It is a seeing that is temporal. There is a knowing of past, present, with implications for the future. It is a seeing that involves risk-taking, an explorative activity assuming vulnerability on the part of the inquirer; for to see, demands by implication, to be seen. It is a seeing that Merleau-Ponty (1962) identifies as being more perceptual than conceptual. To perceive is to attend to multiple sensory information, "translating" the senses into each other (p. 235). The character of such seeing is clearly distinguished from mere recognition. Dewey (1934) explains that recognition entails labeling and categorizing, while seeing entails receptivity—a commitment to finding out about ensuing interactions. Such seeing assumes "inner attention" (Dewey, 1964), manifested through relationships between student, teachers, and subject matter. A teacher seeks ways to draw students into the depth and complexity of subject matter. "External attention" (Dewey, 1964) ignores the movement of thinking, the interplay of students' thoughts, images, emotions, and focuses on recognizing predetermined results and ways of responding. Seeing the "bearings" that foster "inner attention" becomes a notion to work with that participating educators begin to deliberately seek out. In particular, the search for bearings promoting inner attention in teaching and learning leads to the realization that what teachers know often displaces what they see. Debra provides an illustration:

> My eyes are open in a different way. For example, students were working in small groups on specific inquiry tasks related to the study of magnetism. And, one group was playing a game of hockey, utilizing the magnets. This was not at all the intent of the task. My eyes immediately read "messing around, totally off task." But, Margaret [researcher] was there and she liked what she was seeing. I thought about why I did not see hockey as a way to focus and extend the students' study of magnetism. (Focus group workshop, January 21, 2004)

Debra's focus on external attention blinds her capacity to see inner attention. Increasingly, Debra's seeing becomes more receptive, gaining awareness and access to students' thinking (inner attention). She explains:

> In student science journals I started out looking for specific main ideas. Later, I stopped looking for my own agenda and just looked to see what students had learned. One student had started writing about how he would use magnets to construct a toy. Where before I would have said "Off task," I now saw potential for much learning in the toy idea. (Interview, February 3, 2004)

Seeing reorients the control of teaching and learning from being imposed by the teacher, to coming from within the learning situation itself. Dewey (1938) explains the consequences of reorienting seeing in this way: "When external control is rejected, the problem becomes that of finding the factors of control that are inherent within [the learning] experience" (p. 21). And, Dewey's statement is very fitting with teachers' experiences working with the notion of seeing. Dawn comments:

> I think what was hard initially for me was to let the kids loose to do the inquiry. I was petrified thinking it is going to be utter chaos and I have to say I was amazed to find the kids excited to share their work, their ideas, and to actually see the impact. They remember these activities as they keep referring to them over and over again. (Focus group workshop, January 21, 2004)

Evan similarly comments:

> Instead of trying to be strict and cross I found myself actually enjoying student excitement. It was really cool to see kids having fun and really getting it. I have to say I felt more at peace and even a sense of accomplishment that students can do this. (Focus group workshop, January 21, 2004)

And, Debra reiterates:

> I am asking questions of students instead of assuming. So I am kind of relaxed and enjoying their learning and enjoying teaching. I have raised my expectations too. I am like "woo hoo" they really can be responsible for their own learning and it sticks with them. I do not think I was giving kids enough credit. I have definitely learned to be more of an observer instead of feeling like I had to be the controller always scurrying for paper and pencil. (Focus group workshop, January 21, 2004)

Anne confirms:

> While my students were experimenting with hand generators, I was amazed at the learning occurring. One of my students who I was ready to remove from class that day for repeated disruptive behaviors came over to me and said, "Look what I discovered!" It made the day OK; the semester OK. It was wonderful to see him so genuinely excited. And, it provided a way in to talking with him about his learning. (Focus group workshop, January 21, 2004)

These teachers begin to see the inner attention of their students. Such seeing reveals the inherent significance of belongingness to learning on the part of students and also teachers. And, this belongingness cultivates much greater teacher awareness toward the kind of learning situation being created. Seeing foregrounds the significances of student interaction within learning bringing it into greater focus for teachers.

Relational knowing

Teaching and learning relationally entails connecting students, teachers, and subject matter. Students and teachers continually revise and broaden understandings. Relational knowing assumes personal investment, seeking transformation, attending to particularities, relying on collective action, and concomitantly acknowledging reciprocity between self and other. Relational knowing is fundamental to human beings and learning, and thus, relational complexities (the intersections of the social, personal, cultural, historical, political) must be seen as primary in education (Dewey, 1938, 1964; Noddings, 1986,2004; Kessels & Korthagen, 1996; Greene, 1997; Carr, 2000; Cochran-Smith, 2001; Gallego *et al.,* 2001; Sidorkin, 2002; Jardine *et al.,* 2003; Thayer-Bacon, 2003).

Participating teachers work with the notion of relational knowing as the complexities present in all teaching/learning situations deserving to be taken up as productive elements in learning. For example, Andrea recalls her thinking during a particular science class:

> When the class was working on small motor construction I saw groups absorbed in figuring out ways to make it a working motor. As one group met with success, other groups would gravitate over and ask, "What did you do differently? Show us how it works and why." They would take these bits and pieces back to their tables and reconstruct their motors to see if they could get it working. And, if that did not work, they looked to yet others. I got more comfortable with the necessary student movement in the classroom to allow for this learning from each other. And, my planning began to take this into account too. (Focus group workshop, January 21, 2004)

Relational knowing entails valuing personal sense-making alongside collective sense-making. Dewey (1938) describes this as the purpose for learning growing and taking shape "through the process of social intelligence" (p. 72). The recursiveness of this process becomes evident as teachers find themselves reminding students of past learning, figuring into current learning, providing direction for future learning. Dewey's (1938) principle of "continuity" takes life as teachers encourage students to bring personal understandings to bear alongside the understandings of others. Teachers grow increasingly cognizant of their role in prompting and furthering relational knowing in all students through continuity. Dawn relays an incident:

> Previously students had worked at one of six stations with inquiry experiments in place. All students had a chance to write down questions that arose as they worked at each station. But, each student was assigned to a group responsible for addressing the questions from one station. A very serious student at a station with an enclosed Petri dish containing iron filings with a magnet to maneuver the filings around, grappled with the answer to one of the questions: Why did iron filings still stick to the top of the dish even after the magnet was removed? I could tell he was really struggling to locate a plausible reason. The ideas from his peers did not seem to satisfy, and his text did not seem to address this consideration either. I had an idea, but I was not absolutely certain. The next time the class met student groups took turns demonstrating the inquiry station and addressing the questions. The Petri dish group expressed their frustration in regards to the question raised. Another kid just jumped in to the discussion and said, "Well, I know. It

> is because of static." And I thought, "Yes, that is it." The frustrated young man was genuinely pleased that an answer was found. (Reflective statement, January 20, 2004)

The participatory nature of relational knowing is experienced in Dawn's class as collectively students and teacher pursue understandings. Dawn talks with students about the value of each person's participation as an inquirer and how the answer to the question so wrestled with, is a result of this participation. Static electricity's role in other electricity and magnetism experiments came up over and over again and this incident is referenced repeatedly. Continuity is deliberately sought by Dawn, and in turn, by students. In Dawn's class, and other teachers' classrooms, relational knowing means valuing the existing sense-making in learning.

Relational knowing also means that sometimes there are many possible solutions to inquiry problems. Teachers model the importance of attending to differences and learning from these differences. Andrea provides an example as she purposefully asks two groups of students to share their contrary findings followed by a class discussion as to why this might be (Field notes, November 17, 2003). On another occasion Andrea initiates a class discussion by asking one group of students who had struggled the entire class with an inquiry activity to relay the various means explored (Field notes, December 9, 2003). This validated to all that inquiry can be different and that there is much to be learned from the experiences of others, mistakes as well as successes. Relational knowing entails embracing uncertainties as givens within the learning process, allowing the inquirers to contribute to the invention and creation of meaning. Space for speculation, projection, the unanticipated, guides and provides lesson direction arising out of the relational complexities present.

"Education as growth or maturity" as "an ever-present process" (Dewey, 1938, p. 50) is awakened in teachers and students. Learning has a life of its own, taking varied directions in different classrooms, with particular students. The impact extends outside of the science classroom too. Debra explains: "I feel a real connection between electricity and magnetism. I keep seeing electricity and magnetism examples at the store, in my car. It has spurred an interest and created a thirst for knowledge" (Focus group workshop, January 21, 2004). Sandra reports: "Kids went and bought their own magnets. They were comparing types and finding uses I had never considered" (Focus group workshop, January 21, 2004).

Relational knowing becomes apparent within the act of knowing, demanding receptivity to sensory qualities and relations between self and other on an ongoing basis. Teachers acknowledging the multiplicity of knowing, worked with the ensuing intersections. The development of such thinking within situations allows for the discovery of potential. This manifesting character is reliant on teacher capacity to see the relational complexities coming together in particular teaching/learning situations and concomitantly act on these relations. Dewey (1938) emphasizes: "We have no choice but either to operate in accord with the pattern (relational complexities) it provides or else to neglect the place of intelligence in the development and control of a living and moving experience" (p. 88).

Mindful embodiment

If teaching and learning is indeed about building relationships between self, other(s) and subject matter, such reciprocity does not conceive of the teacher deciphering or ordering teaching/learning situations according to a pre-formulated plan. Rather, teaching and learning entails being at the juncture of the movement between self and other. In this way the body-subject is positioned as Merleau-Ponty (1968) describes it in a "crisscrossing"; neither subject nor otherness are bound entities, they intermingle. This crisscrossing demands "mindful embodiment" understood as being in touch with context, finding accordance within lived experience. Such accordance with lived experience takes the form of continuous dialogues between self and all other(s). Sometimes these dialogues are tactile, occurring between participants and materials being handled. Sometimes these dialogues are visual occurring between participants and all that is being viewed. Sometimes these dialogues are emotional, occurring between participants and responses to situations. And, sometimes these dialogues are verbal, occurring between participants and other voices. These dialogues are interconnected and indivisible, superseding distinctions between the head and the hand, the mind and the body, seeing and acting, feeling and thinking, non-verbal and verbal, and calling all participating to enter into the thinking movement of learning. This continuous process of reciprocal interaction and modification is inquiry's significance in teaching and learning. The lostness and foundness of self inherent within this process is constituted within Dewey's (1934) metaphor of the live creature, "the live being recurrently loses and re-establishes equilibrium with his surroundings" (p. 17). An obliterated self is severed from learning, detached from the circumstances in which learning develops. The interplay of a lost and found self is achieved through inquiry in search of "an organic connection between education and personal experience" (Dewey, 1938, p. 25). So Dewey (1938) places teachers at the vortex of this movement, actively facilitating learning connections with students, mindful of two things:

> First that the problem grows out of the conditions of the experience being had in the present, and that it is within the range of the capacity of students; and secondly, that is such that it arouses in the learner an active quest for information and of production of new ideas. (p. 79)

Thus, teachers seek out a working relationship between inner understandings and such mindfulness. Participating teachers evidence that embodied "visceral" understandings are inaugural to teaching for greater inquiry. Sandra clarifies:

> I became increasingly aware of myself as I taught, listening to students for moments to use science terms, watching for moments to validate the inquiry process, anticipating moments that needed my guidance. I became a better inquirer, which I think was critical to help students recognize inquiry at work. (Reflective statement, January 10, 2004)

Visceral understandings of inquiry need to be nurtured in teachers' practices, though, in order to cultivate the necessary mindfulness to teach for inquiry. Observation notes from Debra's class provide insights:

> Debra had students working on a drawing exercise and then experimenting with magnets. Students saw these activities as separate and unrelated but Debra intended them to be deliberately related. Debra was aware of an elemental, intuitive significance to he found in relating these two activities. She had experienced it firsthand in the inquiry workshops. But, she was not able to articulate the significance until she saw the gap in student awareness. The gap forced her to identify the missing connective threads that would build relatedness between these exercises and further learning. (Field notes, December 8, 2003)

Attentiveness to these learning gaps, and a willingness and susceptibility to address them, begin to mindfully embody Debra's practices.[2] A self-consciousness takes hold that is not grounded in a solitary consciousness, but rather a developing consciousness of a consciousness. Merleau-Ponty (1962) refers to this as a fundamental reversibility experienced through one's body, "the fabric, into which all objects are woven, and it is, at least in relation to the perceived word, the general instrument of my comprehension" (p. 235). Merleau-Ponty's commitment to this primacy of bodily experience positions the subject as an actively perceiving, situated being, meeting otherness "in its own self-embrace" (Grosz, 1994, p. 103). The theory/practice conjuncture of inquiry (on the parts of participating teachers) gains textured understandings through such self-embrace.

Assessment as inquiry

A tension quickly emerges in all teachers' practices between trying to value learning processes and the assessment of learning products. Andrea explains: "I tried to create a rubric that outlined everything the assignment covered. But, as I used this rubric I realized that student work looked very similar and yet during the actual lesson I was aware of learning taking all sorts of directions" (reflective statement, November 14, 2003). As such, learning products separated from learning processes. Andrea (and others) begins to see that learning products ought not to be separated from learning processes. The contemporary research literature documents attention to the content of assessments (see McLaughlin & Shepard, 1995; Anderson *et al.,* 1996; Darling-Hammond, 1996; Black & William, 1998a, b; Assessment Reform Group, 1999; Gipps, 1999; Schoenfeld, 1999; Shepard, 2000). While this attention is indeed worthwhile, the focus becomes the assessment product rather than the assessment process. Participating teachers met this tension. Ignoring the process gives little consideration to the changes in classroom assessment practices needed to actually form and inform learning. In theoretical terms, formative assessments offer a language and activities intended to scaffold learning (deliberation activities; brainstorming and questioning; charting what you know, how you know it, and what you might like to know; concept maps; debates and discussions; experimentation; speculative exercises; etc). In practical terms, few educators understand the pedagogical implications of such scaffolding and their responsive roles in the utilization of formative assessments (Wiggins, 1989, 1992; Wolf & Reardon, 1996; Lepper *et al.,* 1997; Delandshere, 2002). Shepard (2000) reiterates this and identifies strategies of *dynamic ongoing assessment, prior knowledge, feedback, transfer, explicit criteria, self-assessment,* and *evaluation*

of teaching that need to be addressed regarding the use of assessment in the process of learning. Importantly, Shepard calls attention to the lack of studies to portray what these strategies actually look like within the concrete realities of learning situations in classrooms. The need to guide teachers in exploring and documenting formative assessment use and response patterns becomes apparent. For example, Andrea follows up on her thinking about the role of assessment in her science classroom:

> With a new group of students I had the opportunity to build on what I was figuring out about inquiry and assessment. I decided to give each student sticky notes and ask students to pass diagrams (they were completing as journal entries) to their fellow students every 10 minutes. Students were to respond to their understandings of the diagrams. When the journal was returned to the owner, they could add more information through addressing the responses. I saw students really enjoying this undertaking and it was taken up seriously by almost everyone. It became a very effective tool for them as they realized the impact their drawing had on each other. We concluded this activity by discussing the following together: (1) the power that drawing and writing together prompted; (2) how the process of drawing and writing out thinking elicited even more questions for consideration and that many of these questions would not have occurred to us otherwise; (3) the evidence of personal experiences and understandings in each person's work; (4) how trial and error helps us each see what we know and what we still need to figure out; (5) how the process enabled each person to make their thinking clearer for themselves and others; and (6) valuing of different ways to see the same work. I am confident I will use this exercise as a catalyst for other student journal entries. (Reflective statement, December 9, 2003)

Andrea identifies elements of attending to processes and deliberately seeks ways to value and utilize these elements to further the process of learning in others. As she models this, her students grow more confident in doing so too.

Assessment began to be taken up by all participating educators as an ongoing responsive undertaking. Sandra was particularly cognizant of responding to student work and thinking in ways to further and deepen learning. Excerpts from a student's science journal provide insights (see Figures 1–4) into how Sandra tried to incite engagement within learning. Sandra's attentiveness to student learning results in greater student deliberation and thoughtful responses. Sandra sees knowledge residing in self-experience and the act of knowing entailing a "reorganizing or reconstruction of experience" (Dewey, 1934, p. 76). This reorganizing/reconstructing process is likened to a dialogue between self, other, and teacher. The discourse entered into is the necessary link to sense making. This emergent dialogic nature characterizes assessment in the making, derived from the learning process itself.

The lived terms of inquiry

The working notions of seeing, relational knowing, mindful embodiment, and assessment as inquiry, fold into each other, setting inquiry in motion. Teachers' actions manifested through these working notions reveal the significances of practitioner knowledge within the process of furthering learning. The research literature identifies many dimensions of practitioner knowledge such as "declarative and procedural

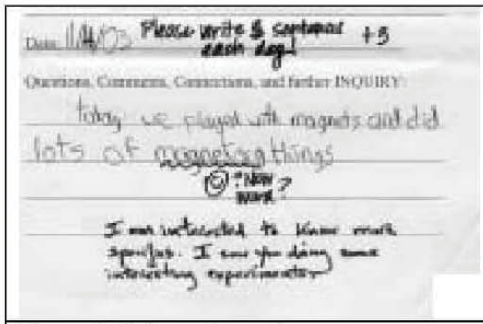

Figure 1. Science journal entry

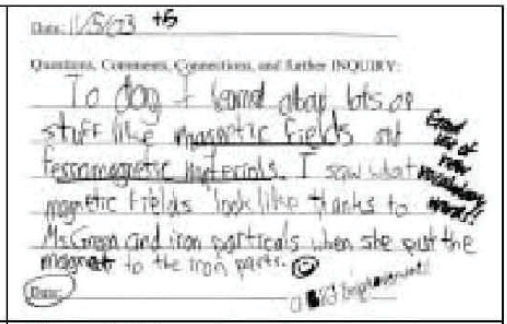

Figure 2. Science journal entry

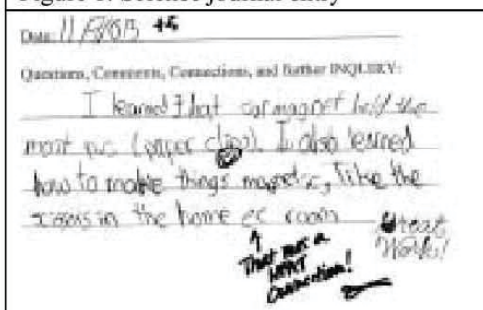

Figure 3. Science journal entry

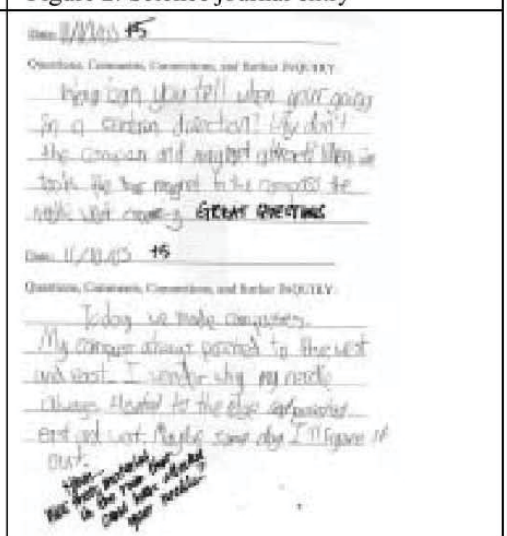

Figure 4. Science journal entry

knowledge" (Peterson & Comeaux, 1989), "personal theories" (Carter, 1990; Cole & Knowles, 1993), "images" (Elbaz, 1983; Clandinin, 1988; Calderhead & Robson, 199l), "practical and formal knowledge" (Fenstermacher, 1994), "craft knowledge" (Calderhead, 1991), and constructivist understandings emphasizing conscious and systematic meaning construction (Calderhead, 1989; Tom & Valli, 1990) leading to a reframing of teacher experiences (Schon, 1995; Tom, 1997; Korthagen, 2001; Loughran, 2002). Although this extensive research reflects significant growth in understandings of knowledge, basic questions about the nature of teachers' knowledge still remain. Munby *et al.* (2001) state that the nature and development of that knowledge is only beginning to be understood by the present generation of researchers in teaching and teacher education. Many current educational researchers concur (Darling-Hammond, 1996; Hargreaves, 1998a; Ball & Cohen, 1999; Darling-Hammond & Sykes, 1999; Zeichner, 1999; Clark, 2001; Cochran-Smith, 2001; Gallego *et al.,* 2001; Hiebert *et al.*, 2002), establishing the complexity of practitioner knowledge. As Hiebert *et al.* (2002) point out "Professional knowledge requires a mechanism for verification and improvement" (p. 8). The process character of change

in professional development has been neglected (Fullan & Hargreaves, 1992; Hargreaves, 1994, 1998b; Desfoges, 1995; Kremer-Hayon & Zuzovsky, 1995; Fullan, 1998,2000; Russell, 1999; Richardson & Placier, 2001). Some recent studies begin to document successful professional development efforts in response to the community's call to examine how effective change can occur through professional development (Leiberman, 1996; Darling-Hammond, 1997; Kennedy, 1998; Garet *et al.,* 1999, 2001; NSDC, 2001; Le Ferre, 2002). Teacher content knowledge is a key feature identified as being overlooked. The interplay between content knowledge and how children learn is an important mix in effective teaching/learning practices that is just beginning to be systematically studied. Current researchers argue that teachers lack strong content-specific teaching skills and this constrains effective practices (Corcoran, 1995; Reynolds, 1995; Kennedy, 1998, 1999; Rhine, 1998; Snow, 2001; Hiebert *et al.*, 2002). Our study's deliberate connection between science content knowledge (utilizing the resources of STEM personnel) and teaching/learning practices confirms the significance of content knowledge to teacher professional development. Greater confidence in subject matter translated into greater willingness to embrace process in student learning. Positioning practitioners and researchers working alongside each other attending to learning process produces meaningful changes in educational practices. As such, educators assume teacher/researcher roles leading to designing, conducting, and documenting inquiry in their science classrooms, building teacher content and pedagogical knowledge, and teacher capacity to document and foster growth in student learning. The role of the teacher must not be underestimated or dismissed. It is teachers that we depend on for "the widening spread and deepening hold of the scientific habit of mind" inquiry (Dewey, 1910, p. 19 1). We find that the working notions are powerful vehicles for teachers "widening and deepening" science inquiry practices.

Our study confirms the central importance of practitioner knowledge as teachers locate the lived terms of inquiry within their middle-school science classrooms. Permeating all six cases, the lived terms of inquiry are evidenced as participatory in nature, vigilant to the question(s), organic in form, and always turning back on self. These terms are reflexively experienced, acting as catalyst authorizing inquiry as teachers experiment directly with the working notions of seeing, relational knowing, mindful embodiment, and assessment as inquiry, over and over again in their daily practices. Therefore the opportunity to "see, and see again" (Collingwood, 1938) inquiry in practice, assumes participation. Gadamer (1981) clarifies that such participation "is a genuine sharing in an event, a real being present" (pp. 17–18). Indeed, the voices and experiences of teachers evidence knowing acquired through the act of participation. Elucidating theory/practice relations concerning inquiry demands participation. Gadamer (1984) notes that although participation literally means "taking part" its dialectic:

> Consists of the fact that participation is not taking parts, but in a way taking the whole. Everybody who participates in something does not take something away, so that others cannot have it. The opposite is true: by sharing, by our participating in the things in which we are participating, we enrich them; they do not became smaller, but larger. The

> whole life of tradition consists exactly in this enrichment so that life is our culture and our past: the whole inner store of our lives is always extending by participating. (Gadamer, 1984, p. 64)

Similarly, taking the whole of inquiry entails teachers simultaneously seeing with relational knowing, mindful embodiment, and continual assessment, extending and expanding understandings of inquiry in action. And, as Risser (1997) emphasizes, participation is not simply a "going along; rather in participation, we become vigilant to the question" (p. 116). Such vigilance is what it means to be an inquirer, actively engaging in creating meaning, demanding a presence within the moment, taking in, receiving, and acting, as situations call forth. Learning, thus, is organic; the process determining the form as it evolves, and vigilance, is thus about reciprocity; the continual improvising of relations between self and other. Gadamer (1964) relays this inbetweenness as "self-understanding always (occurring) through understanding something other than the self" (p. 97). This turning back to self is the expression of inquiry, offering consummatory moments, leading to further inquiry.

These reflexive terms of participation, vigilance, organic form, and turning back on self, give "flesh and blood" to the theory/practice interplay within inquiry. Too often, as Kessels and Korthagen (1996) point out, theories are abstract, lacking

> Flesh and blood in a very literal sense; they do not have a face, nor a repertoire of actions. They have no temperament, no personal characteristics, no history, no vices, and no virtues. They cannot be seen in action, nor talked to, nor criticized, nor admired. In short, they do not have any perceptual reality; they are just concepts, abstractions. Therefore, they cannot be identified with. (Kessels & Korthagen, 1996, p. 21)

But, rather, the flesh and blood of inquiry takes on new life in teachers' and students' work and thinking, "changing the conception of what constitutes education" (Dewey, 1904, p. 30), and professional development, for all involved. This study suggests a professional development model embracing the "operative and active" nature of inquiry in its design, holding implications across all learning and disciplines. A final excerpt from field notes in Dawn's class bears witness:

> Students were reading a section from the science text on galvanometers. There was a noticeable level of student intolerance for reading words with no concrete exercises facilitating resonance and deeper understandings. Dawn had returned to the text with a sense of urgency to provide self-assurance students had covered the material for the upcoming mandated test. Students called out, "Too difficult"; "I do not get it." There were lots of questions and observable frustration. Ninety-five per cent of the class put their hands up to indicate they did not understand the reading. (Field notes, January 9, 2004)

It seems that students in Dawn's class acquired habits of working that they now expect to be the norm. Previously, these very students regularly read from the text, rarely with any observable interest and involvement. Now, a presence is required that no longer permits them to read from the text and simply accept that it makes little sense. Dawn immediately acknowledges the difference in her students and confronts the impossibility of retreating to presence-less teaching/learning practices. Such presence of

minds is increasingly embraced as teachers and their students experience the terms of inquiry and the ensuing power of being an inquirer finding "the path of experiment and induction by which science develops" (Dewey, 1964, p. 189) ... and, all learning.

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Notes

1. See Buck *et al.* (in press) for a more detailed account of the content/inquiry workshops.
2. See Macintyre Latta and Buck (in press) for a more detailed account of mindfully embodied teaching/learning practices

Contributors

Margaret Macintyre Latta is an associate professor in teacher education and curriculum whose scholarship and teaching foregrounds neglected epistemological assumptions in teaching and learning.

Gayle Buck is an associate professor of science education interested in relationships across learner diversity and science.

Diandra Lesley-Pelecky is an associate professor in physics and astronomy, examining intersections between science content knowledge and pedagogy.

Lora Carpenter is currently teaching middle level science and was the research assistant associated with this project.

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