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Abstract

This two-year study focused on the lived terms of inquiry in middle-school science classrooms. The conditions that enable teachers to see and act on science learning as ongoing inquiry were deliberately sought in Year 2. Nine science teachers participated in search of capacities connecting curriculum, teaching, and assessment for greater student and teacher inquiry. An online logbook chronicled this search, serving as a dialogic medium revealing a movement of teachers seeking out and seizing back possibilities for teaching and learning in relation to the given realities of classrooms. The nature and role of formative assessments in support of learning were encountered as the obstacle to be worked out in teachers' practical action. The necessary interpretive eye and capacity to act in accordance with the dynamic character of formative assessments became the task at hand for teachers and researchers. This task demanded artistic teaching visions, attending to the creation of student meaning on an individual and collective basis. The difficulty, alongside the necessity, of educating artistic teaching visions offered glimpses into how formative assessment use holds potential to restore the participatory dynamic integral to learning. The

philosophical/theoretical ground of arts based educational research was found to offer much potential to science inquiry, linking process-product-learner in support of formative assessment use and offering implications for a participatory mode of professional development.

Introduction

This article focuses on assessment as an integral part of instruction, supporting and enhancing learning. Such means of assessment assumes that learning products cannot be separated from learning processes. There is much within contemporary research literature documenting relationships between assessment and learning (e.g. Assessment Reform Group, 1999; Black & William, 1998a, 1998b; Shepard, 2000). While acknowledging that this attention is indeed worthwhile, the focus for teachers and learners often becomes the assessment product rather than the assessment process, with little consideration given to the changes in classroom assessment practices needed to actually form and inform learning. In theoretical terms, formative assessments offer a language and activities that are intended to scaffold learning (deliberation activities; brainstorming and questioning; charting what one knows, how one knows it, and what one 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 (e.g. Delanshire, 2002; Shepard, 2000; Stake, 2004). Shepard (2000) identifies strategies of *dynamic on-going 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. But, she calls attention to the critical need for studies to portray what these strategies actually look like within the concrete realities of learning situations in classrooms (p.12). Shepard and other contemporary educational researchers also argue against accountability narrowly conceived as external, standardized expectations that ignore the inherent relational complexities of the social, cultural, historical, and political configuring into teaching and learning (e.g. Black & William, 2003; Cochran-Smith, 2001; Gallego, Hollingsworth, Whitenack, 2001). Gallego et al. concludes that “without opportunities to develop the capacity for relational knowing teachers and teacher educators will never be able to develop such capacities” (p. 261). Our ongoing work alongside practicing teachers, focusing on the lived terms of inquiry in middle school science classrooms and the concrete implications for assessment practices, reiterated Gallego’s concern and we became cognizant of Black & William’s (2003) call that any change must be worked out in teachers’ practical actions.

Context and Problem

Two of the authors are teacher educators. One is involved with arts-based educational research considering the roles of aesthetic considerations within teaching and learning, and the other is involved as a science educator. The third researcher is a graduate student and practicing artist and teacher. Collectively we became interested in negotiating a conjoint professional development relationship with participating educators enhancing student inquiry within middle school science classrooms. We turned to Duschl and Gitomer (1997) documenting a pedagogical strategy “the assessment conversation” as a means to greater teacher insights into student understandings as a springboard for instruction. While Duschl and Gitomer found significances for student instruction through ongoing conversations with teachers gaining access to student thinking, their study noted four conclusions that were problematic for teacher and student inquiry: 1) the teaching of science is “dominated by tasks and activities rather than conceptual structures and scientific reasoning” (p. 65); 2) teachers’ views of science emphasize topic coverage; 3) “reconceptualizing the relation between assessment and instruction is a major hurdle” (p. 65); and 4) the significant role of teacher content knowledge and its relation to classroom teaching/learning practices. These conclusions embraced the collective problem we met and sought to address involving participating educators in conjoint professional assessment conversations. Indeed, we found that in our work over two years the “major hurdle” of a fitting relation between assessment and instruction seemed difficult to achieve even if participating teachers found professional development supports enabling greater student inquiry in classrooms.

Reflexive Methodology

The lived terms of inquiry for 9 participating middle-school science teachers in a public urban school system were documented over two years. Participants understood this to be a professional development opportunity for middle level teachers. This professional development opportunity was a collaborative effort between university faculty, the school district, and middle-level science teachers. All participating teachers taught at the sixth-grade level, followed the same district-defined curriculum, and their students completed the same district-wide science exams. School district objectives for sixth-grade science content formed the shared purpose. Participants took part in an interrelated set of experiences that included content immersion workshops through inquiry, collaborative reflection on the immersion experiences, planning sessions for classroom instruction, follow-up field experiences with on-site collaboration with teacher educators and ongoing reflection documented in teacher/researcher email correspondences, a teacher/researcher online logbook, summative focus-group discussions, and individual interviews over Year 1 and repeated in Year 2. Dialogue was the fundamental means utilized to initiate and extend understandings of inquiry in a continuous responsive interchange. Data was collected throughout these experiences. In particular, data from the teacher/researcher online logbook documenting critical teaching/learning incidents, teachers’ lesson plans

and associated resources, students' learning artifacts, and transcriptions of audio taped interviews and focus group workshops, enabled all of us to intermittently assess the insights gained and the direction for our study to proceed on a regular basis. Thus, a reflexive approach (Alvesson & Skoldberg, 2000) to data collection and analysis was considered essential, operating both inductively and deductively throughout, providing means to address the interface between the empirical data collected, its interpretations, and the research literature situating the study and the traditions inherited and being reconstructed. Such ongoing reflexivity was a catalyst for conversation across participants. The insights generated through reflexive analysis over Year 1 led to our plan for action in Year 2.

A Review of Year 1

Throughout Year 1 (2003-04) of the study, instilling teacher authority (as inquirers themselves) became imperative if greater student inquiry in science classrooms was to be realized. Instilling such teacher authority entailed creating first hand science inquiry and content knowledge opportunities for teachers, alongside delving into a theoretical/philosophical framework supporting and articulating the terms of inquiry. These efforts increasingly authorized more and more inquiry in classrooms. The lived terms of inquiry for participating teachers and the consequences for learners and learning were experienced directly (see Buck, et al., 2007; Macintyre Latta, et al., 2007, for detailed account of this study). Year 1 involved middle school science teachers committed to creating learning encounters foregrounding scientific inquiry, connecting thinking processes and learning products/artifacts, articulating teacher/student thinking throughout. The specific aim was to make the inquiry process discernible to teachers fostering growth in learner understandings and teacher insights into these understandings.

Placing inquiry as an educative process to be worked with at the core of the thinking and experiences of participating educators, yielded working notions cultivating, sustaining, and nurturing inquiry in teachers' practices in Year I. The working notions of *seeing*, *relational knowing*, *mindful embodiment*, and *continual assessment* emerged from teachers' searches as embedded components of inquiry that became ways of living and being in classrooms. Working with *seeing* positioned teachers to foster inner attention in students so that the control for learning came from within the learning situation itself. Working with *relational knowing* positioned teachers to find intersections among student, teacher, and subject matter. Working with *mindful embodiment* positioned teachers to concretely feel the lived terms of inquiry alongside their students. Working with *continual assessment* positioned teachers to support and enhance learning processes. These working notions created a framework for teachers and their students to question and critically analyze teaching/learning practices, acting as catalysts authorizing more and more inquiry in teachers', and then students', practices. The acquired confidence in the process character of inquiry manifested teachers' demands for fitting assessment

practices for their students. And, indeed, teachers identified typical assessment practices in place as coming up short in this regard.

Participating teachers expressed inadequacies regarding a mismatch between assessment practices and student inquiry were confirmed as we collected and examined assessment artifacts in use, despite attempts to support inquiry in these classrooms. Of over 4000 formative assessment artifacts from students incorporated into this ongoing inquiry project with middle school science teachers, less than 5% of the artifacts documented any visible evidence of teacher responsive feedback intending to further student thinking. Instead, a grade or number was typically noted becoming a percentile ranking in a pre-determined formula for a final grade on a unit of study. Evidence of student thinking was present as most artifacts documented some personal learning connections but this was curtailed by a dominating theme of sameness permeating student work. In other words, student science learning artifacts recorded findings in graphs, diagrams, charts, and reports that were alike in content and form. Despite the large number of artifacts collected, they actually provided little insight into their role in forming and reforming learning and in fact were seen by teachers as quite disconnected from the actuality of the student inquiries conducted. Both teachers and researchers came to the conclusion that finding fits among curriculum, teaching, and assessment were integral to our future work together.

Year 1 of the study conveyed that the conditions that enabled teachers to see and act on science learning as ongoing inquiry were still lacking despite 1) ongoing professional development opportunities for participating middle school science teachers to consider the conceptual structures and scientific reasoning they were asking students to engage; 2) providing concrete experiences that suggested resources and multiple ways to teach for contextually relevant connections between students and subject matter; and 3) permeating all efforts with content knowledge enhancement aimed at fostering teaching confidence. While not dismissing the importance of these related and interdependent efforts, the key objective of cultivating the artistry within teachers' identities began to transcend these efforts as an impoverished need we saw as critical to addressing the formative assessment hurdle.

Year 2: The Plan for Action

Researchers and participating educators conjointly decided that giving expression to the character of formative assessments might render greater visibility to their forming/informing/reforming nature and role within the learning process. Middle school science classes already engaged in the ongoing inquiry project (Year 1, 2003-04), deliberately attending to the processes of student learning, provided the necessary learning contexts to do so over Year 2 (2004-05). Nine participating teachers examined the interface between the classroom products of 347 adolescents and the targeted conceptual understandings guiding their classroom-based science inquiries over 2 units of study, electricity and magnets, and earth's changing surfaces. Each teacher designed his or her own particular

formative assessments and ways to respond to completed student work, attending to judgments -in-progress. Student artifacts, alongside teachers' understandings of learners' intents behind the artifacts, revealed a potential classroom dialogue that is often overlooked in science educational research. It is such a dialogue that attends to the relationships across content, learners, learning, and the forms learning produces. But, we were increasingly cognizant that the capacity to act on these relationships depended on participants seeing them in the first place, before acting on them was even a possibility. We examined what these "seeing" conditions might be and what they entailed for the practices of educators attempting to negotiate fitting relationships among curriculum, teaching, and assessment.

Educating Artistic Visions

Process is integral to scientific inquiry. Inquiry is a creative enterprise, resisting imposed routine, demanding reason alongside ongoing judgments, consideration of alternatives, openness, and inventiveness. Such qualities are integral to formative assessments, prompting and furthering learning. And, such qualities are at the heart of Eisner's lifelong primary concern for educating artistic vision, "so that the world man [sic] encounters can be seen as art"(1972, p. 272), calling for seeing with potential: "To succeed the artist needs to see, that is, to experience, the qualitative relationships that emerge in his or her work and to make judgments about them" (2004, p. 5). Educating an artistic vision on the part of the 9 participating teachers, seeing and attending to the relationships across content, learners, and learning within teaching/learning situations as the sustenance for creation of meaning, was the immediate undertaking.

Derived from the work in Year 1 alongside middle school science teachers the "working notions" gave lived meaning to the participatory character of inquiry. Teachers understood that the working notions of *seeing*, *relational knowing*, *mindful embodiment*, and *continual assessment* were interrelated and interdependent within the act of teaching. The intent of these working notions in Year 2 was to act as lenses positioning teachers to act on the learning relations and judgments inherent within inquiry. Teachers were encouraged to utilize each notion as a vehicle to reconceptualize student learning situations and artifacts of learning.

In Year 2 the working notions became the eyes of an online logbook in which teachers entered into the assessment conversation viewing and responding to others' thinking and documentation of teaching/learning accounts on a weekly basis over 9 weeks during a curricular unit of study regarding earth's changing surfaces. A case-study approach was utilized with each participating teacher and classroom constituting a case for analysis. Two primary data sources were utilized from each case site: the online logbook entries by participating teachers and researchers, and teacher designed student formative assessments. The online teacher/researcher logbook entries, followed by the student formative assessment artifacts, were examined reflexively across three phases of data analysis. Phase I focused on the individual cases, responsive to the emergent features

of each setting, blocking and labeling thematically all data. Phase II entailed a cross-case analysis identifying themes common to all cases. Phase III entailed a group analysis of data focused on the findings and implications for enhancing educators' understandings of formative assessment use furthering student learning. Reflexive data analysis, operating throughout in an ongoing dialogic interchange, awakened teachers and researchers to process and offered a "fresh cut into the complexity of the situations" we faced (Caputo, 1987, p. 261). Examples of these reflexive data "cuts" from the online logbooks and then the student formative assessment artifacts follow.

What Do the Eyes of an Online Logbook Reveal?

Seeing. Phase I analysis of the teacher/researcher logbook entries indicated teachers incorporated multiple informal means of assessing formative understandings such as exercises specifically designed to draw students into the depth and complexity of subject matter, ongoing dialogue, listening to students' conversations, generating questions, and cognitive stretching exercises to deliberately make learning connections. Phase II analysis clarified that these devices were very familiar to teachers but their capacity to read them for insights into student learning was less familiar. It demanded reorienting seeing from a summative assessment decision to a window into student's perceptions, experiences, and understandings, with these being springboards to further learning. Reorienting teacher seeing entailed valuing students' interests and thinking. Reorienting teacher seeing entailed teachers actually acting on students' connections and learning directions. Reorienting teacher seeing entailed finding ways to sustain and grow students' learning. Seeing learning situations as continual opportunities to access and reassess students' understandings took on an artistic forming/informing/reforming movement in which the given particularities of students, content, and context became the materials of the inquiry to work with for teachers and students. A representative example from the online logbook is as follows:

Teacher Entry: I plan to introduce the notion of erosion utilizing pieces of steel wool observed under different conditions. I am surprised to find out that students do not know what steel wool is or what it might be used for. So, I get a large roll of it and pass it around for everyone to touch and observe. Students make connections to other steel items such as bikes and cars and I direct the conversation toward rusting as an example of erosion. Students are able to connect exposed steel to erosion. I can see that speculations are more abundant as students make these connections. We proceed with the experiment soaking pieces of steel wool in different containers and under different conditions. Both containers have lids. Spontaneously students select names for each piece of steel wool and so we place "Bob" soaking wet in the closet so that no light will affect his erosion and it is decided that

he needs to be there for the remainder of our unit of study; we place “Fred” also soaking wet on the window sill for only 3 days but with plenty of sunlight. Time is set aside in each class for the next 3 days for everyone to record in personal science journals the placement of each container, the conditions, noting observations and changes, and longer term predictions. Everyone arrives at class anxious to see dramatic changes. I can see that students have to learn to be patient and attend closely. One student initiates his own steel wool experiment, providing a small container of sand that he places inside another container holding some water in the bottom. The steel wool is placed on top of the sand, remaining dry, but close to water. This container also has a lid. The class as a whole takes an interest in this student initiated experiment and so it is named “Fred-Bob” and given a seat by the window to see if the sun might provide condensation inside the container. After 3 days and with growing interest and some documentation of Fred breaking down, students decide to extend Fred and Fred-Bob’s stay to the same amount of time as Bob in order to really compare results of erosion. The daily recording in journals takes about 10 minutes at the beginning of each class. Students’ notes become more and more detailed and they realize over time that the notes are revealing an important story of process that our individual and collective memory cannot match. Daily, I use the notes from students to raise questions, to synthesize observations, and to encourage projection and speculation. (online logbook, 9/19/04)

Researcher Entry: Seeing entails a commitment to fostering inner attention in students so that the control for learning comes from within the learning situation itself. Genuine curiosity in action is happening in your classroom. And, this curiosity is fueling careful observation, astute questions, learning connections, and further inquiry. What I find so interesting and exciting is that an undeniable student belongingness to learning takes over and provides direction with the control for learning coming from within the learning situation itself, rather than control being entirely teacher imposed. (online logbook, 9/20/04)

Relational Knowing. Phase I analysis evidenced that students’ personal interpretations, drawing on past and present experiences, were understood by teachers as figuring into all learning. Emphasizing, rather than avoiding or disregarding these relationships, became a means to further learning. Phase II analysis identified teachers attempting to work with the learning relationships being negotiated as thinking in process guiding the inquiry. Formative assessments necessarily needed to reveal student-learning connections and teachers needed to understand the impact of their responses within this process. In turn, students tentatively took up the conversation begun and boldly documented their sense making much more sincerely. Increasingly, they concerned

themselves less and less with the “way” the learning process ought to proceed and more with recording the particulars of the specific learning experience. Students looked forward to teachers’ responses to their thinking and the conversations revealed speculation, projection, the unanticipated, increasingly guiding both student and teacher thinking. A representative example from the online logbook is as follows:

Teacher Entry: We make an initial field trip around our school to map out the landforms, vegetation, and any visible landmarks as a way to begin this unit on earth’s changing surfaces. I am surprised how many times as a class we are able to refer back to this experience. Today as we discuss mechanical weathering students recall the cement pad in the far northeast corner of our school field. Students explain that this site is used as a shot-put location. The cement is cracked through the middle and plants are growing in the cracks. I affirm that indeed this is an example of mechanical weathering. The connection to this prior learning experience is visible and energized. Seeking out learning connections carries into the viewing of pictures of well-known buildings and places in our town recording evidence of weathering. Questions of why sandstone and limestone are used as building materials come forward. Students talk of visiting these sites on the weekend to look more closely. Retaining ideas and revisiting ideas enables learning connections. Relevancy to students’ life worlds builds learning relations that are not forgotten. I am much more deliberately involving past learning experiences as a class and particular learning experiences from individual students, as I plan and conduct lessons and respond to students. (online logbook, 9/04/04)

Researcher Entry: You are seeking out the intersections among student/teacher/subject matter. The reference to the shot-put location is a powerful example of how simple, and yet very real, learning intersections can take. You planted an example/image of mechanical weathering that many will not forget. What about having students take photos of weathering examples they locate on their own? How could these photos become interactive for everyone? (online logbook, 9/06/04)

Mindful Embodiment. Phase I analysis portrayed lived and felt understandings of the nature of inquiry as being integral to teachers creating the learning conditions and contexts to foster such qualities in their students’ thinking. Teachers much more readily adapted and changed their teaching strategies and expectations as they experienced firsthand the power of being an inquirer themselves and considered how this could impact their own classrooms. Phase II evidenced a commitment to inquiry as an

adapting, building, changing process becoming a participatory way of living and being in classrooms. And, acceptance that living in these ways in classrooms is not easy for learners or teachers, but the genuine work of inquiry, took shape as embodied habits were slowly instilled in which patterns of inquiry become the expected norm for students and teacher. A representative example from the online logbook is as follows:

Teacher Entry: Working in pairs students design a grass farm (using a cross section of varieties of seed) in a plastic box that incorporates one hill. I am planning on them using the idea of contour plowing. But, what I have told them so far is that after we all get grass growing, there will be a big rain storm. We will then examine which designs best prevent soil erosion (thank you, G, & L for the idea). I am not sure students make any connections to contour plowing but I bite my tongue because I am thinking that they might want to do some plowing as they see what and how the grasses grow. I am really aware that trying to understand these concepts from the text with a few illustrations is not really making much sense to my students. I am trying with this idea to help students actually experience some of these abstract concepts. Thus far, it has been a little chaotic and I am really taken back by how few of my students say they have ever grown anything. There is enthusiasm and interest and I am trying to channel it. (online logbook, 10/03/04)

Researcher Entry: The lack of play and exploration with the outside world keeps surfacing in all participating classrooms. I think this is all the more reason to create some of these lived and felt learning opportunities for students. The chaos will dissipate as students become more familiar with working in these ways. As students examine their particular farm and the progress of their crops, encourage them to speculate on ways to enhance crop growth. Perhaps paying attention to the differences between farms may foster ideas. (online logbook, 10/04/04)

Continual Assessment. Phase I indicated teachers and students began to seek evidence of learning process in learning products. This seeking documented much more willingness to examine the specifics of individual student understandings and utilize these understandings as the basis to negotiate an ongoing reciprocal conversation intended to grow student thinking. Students realized over time that learning can be documented differently, and that there was much to be gained through paying attention to the multiplicity of understandings. As such, teachers and students became more comfortable with learning represented through multiple layers and levels of understandings. Phase II revealed that the comfort stemmed from individual pride in validating and enlarging personal thinking, very much facilitated by the collective

concern. A spirit of inquiry emerged acting as a catalyst for all. A responsibility to self emerged as the human accompaniment of inquiry (Boisvert, 1998). A representative example from the online logbook is as follows:

Teacher Entry: Monday is our last observation of our steel wool samples in their containers. We wish we took photos to record the process. The cool part of this class is the realization on all of our parts as to how valuable everyone's journal notes are to our concluding discussion. The end results are compiled for each experiment and this prompts conclusions and implications....variables are considered and reconsidered such as possible temperature fluctuation by the window for Fred and Fred-Bob and maybe a temperature consistency for Bob. Students point out that next time each site should have a temperature gauge with regular recordings taken. Students wonder about the amount of water used to soak each piece of steel wool and consider that a good idea might have been to weigh each piece as was done in the soil sampling activity on a previous day. (online logbook, 9/26/04)

Researcher Entry: Student involvement and care is evidenced in the design of the experiments and the documentation throughout. Individually sense making is occurring but also the collective thinking movement created is powerful. What aspects are you attentive to that contribute to the force of this collective movement? (online logbook, 9/27/04)

The Interpretive Eye of Formative Assessment

The working notions of *seeing*, *relational knowing*, *mindful embodiment*, and *continual assessment*, serving as lens/ways for participating teachers to access capacities to further student learning, demanded significant time on all participants' parts (teachers, students, and researchers) to cultivate the habits of artistic vision. Educating an artistic vision on the parts of teachers asked them to recognize and attend to the creation of student meaning, engaging in ongoing teacher/student conversations concomitantly on individual and collective bases. Entering into the discourse relationships suggested an organization and form for inquiry to take, way-making in a constant interchange between teachers and students. Thus, the assessment conversations relayed on the online logbook took multiple forms in classrooms, but a thematic analysis of the content of the online logbook in Phase III of data analysis distinguished temporality and interplay of student/teacher experiences and understandings as increasingly valued in student learning. The costs of losing the relational interplay gathering together in a learning space were increasingly visible to participating teachers. The costs of disregarding the past-present-future fusion of learning moments were increasingly visible to participating teachers. Teachers documented a loss of student internalization of concepts, a loss of

attention to the particularities of students and learning situations, and a loss of purposeful, meaningful student involvement.

A “space-time” concomitant reciprocity permeated participating science teachers’ search for assessments forming/ informing/reforming learning. Dewey (1938) explains that separating the spatial from the temporal is destructive to this process character, foregrounding how the spatial and temporal must operate together. It was this unity of space-time that participating science teachers found to be integral to their formative assessment tasks. These tasks then became hermeneutic in nature pursuing “the theory of the operations of understanding in the relation to the interpretation of the texts” (Ricoeur, 1991, p. 53). Participating teachers reoriented their readings of learning artifacts from asking, “What is known about pre-determined concepts or terms?” to “What does this artifact reveal about the learner and her/his understandings?” The concern was not so much with grasping for student factual knowledge as with apprehending possibility. As Ricoeur (1991) clarifies the work of interpretation “does not transform it into something else, but makes it become itself” (p. 67). Thus, a unique structure for student understanding was revealed through the online logbook. Student expression was seen as articulating the particular understandings at play.

What Do Student Formative Assessment Artifacts Reveal?

Phase I content analysis at each site organized the student assessment artifacts sequentially over the curricular units of study involved. In total 347 students participated in 9 classrooms with an average of 15.54 learning artifacts collected from each student. The first step in Phase I entailed each formative assessment artifact being examined for trends and differences across all student artifacts associated with each assignment and within each case site. The researcher taking on this task was not directly involved with participating teachers or classrooms and so looked only at the artifacts for visible evidence of alignment between assignment expectations and student work. Distinguishing features of all formative assessment artifacts were also noted. The coding scheme ascertained the specifics of content (recording terms and notions utilized by students), materials (the abstract ideas and concrete resources students incorporated to explain their content knowledge), and form (how the process of understanding was depicted). The second step of Phase I documented any relationships evidenced across content, materials, and form for each learning artifact. For example, any student attention to personal experiences relaying internalization of understandings were noted, evidence of student integration of previous learning informing and enlarging understandings, the particularities of the direction of student learning, and inferences and speculative student comments were recorded. The third step of Phase I entailed a final judgment derived across steps one and two for each learning artifact indicating either no indication of student understanding, little understanding, limited but some evidence of student knowledge construction, and thorough understanding. The researcher’s attention then turned to visible evidence on the student learning artifacts of teachers’ responses to

student content understandings, ideas and materials utilized, and the forms learning took, with the researcher recording in Phase II what and how teachers provided feedback to students. A second researcher then repeated the 3-step process of Phase I followed by Phase II and then both researchers compared notes and reconciled differences.

Cumulative analysis of Phase I suggested the collection of student artifacts did not allow for an adequate understanding of student learning. Sameness permeated across student artifacts with Phase I (step 1) analysis indicating that students noted the content terms and notions documenting their thinking similarly, and Phase I (step 2) analysis evidencing minimal visible increase of personal sense-making processes. Phase I (step 3) indicated that of the extensive amount of student work generated during the study, an overwhelming majority allowed for little/no understanding of student learning. For example, the student-work collected in one classroom contained 101 student-generated artifacts. Of these, 27% were coded as artifacts that provided no understanding of student learning, 49% were coded as artifacts that provided little understanding, 25% were coded as artifacts that revealed a limited understanding of students' knowledge construction, and none of the artifacts provided a thorough understanding of student learning. The percentages for other teachers reflected similar percentages of the latter two categories, even if the percentage of artifacts was significantly different for the first two categories. For example, the student artifact collection of another classroom contained 378 student documents. Of these, 70% were coded as artifacts that provided no understanding of student learning, 3% were coded as artifacts that provided little understanding, 25% were coded as artifacts that revealed a limited understanding of students' knowledge construction, and 2% of the artifacts provided a thorough understanding of student learning. Unfortunately, it is the artifacts from the last two categories that are necessary in order to foster learning.

The lack of artifacts allowing for an understanding of student learning was a continuing concern. Phase II analysis indicated that teachers tentatively began to respond to student thinking indicating directly on the artifacts further considerations and questions, praise, challenges, and re-directing guidance, but such feedback remained limited and increased only after researcher prompting. A vigilance and persistence was required on the parts of teachers and researchers, furthering formative assessment use as a vehicle to gain access to individual and collective sense making. Field notes (accompanying a unit of study on electricity and magnets) of one teacher's struggle provided an illustrative example of the educated vision needed in order to attend to the given relationships within formative assessments:

Andrea is obviously proud of her initial translation of formative assessment use in her science classroom. She has students diagram their understandings of fuse boxes. As students complete the task, the diagrams circulate to 3-5 students for feedback. A sticky note chronicles student responses on each diagram. Andrea's pride

stems from the boldness this has taken for her to surrender some control of the learning and assessment process. And, she is at first very pleased with perceived student seriousness in approaching this task. But, as we examine student responses it becomes apparent that students tended to copy the tone and rhetoric of the first response on the sticky notes, and that the vast majority of these responses were about the colored pencils utilized and perceived artistic ability, and not about the content of the diagrams themselves. In fact, other respondents chastised one student who attempted to ask questions regarding the content of another student's diagram for being too critical and unsupportive. So, comments like "Nice colors" and "These are my favorite colors too", dominate the sticky notes. Andrea offers an assessment conversation starter but she did not see the supports needed to enable students to take up the task as a conversational medium. Students did not interpret the task as an invitation to conversation. Rather, they respond with what is safe and fast, focusing on the polished products disregarding the thinking exposed. (Field notes, 12/9/03)

This exercise was initially identified by the teacher as formative assessment, but if left as it played out, there was little about it that formed/informed/reformed the learning in that classroom. We had to examine each diagram closely to find traces of exposed student thinking. All participating teachers looked at these artifacts to note what was present, what was unclear, and what questions needed to be asked. This exercise forced everyone to encounter the reconceptualizing work ahead, addressing the major hurdle of formative assessment with a willingness to push each other's thinking.

The Dynamic Character of Formative Assessments

Greater teacher attention to Dewey's (1938) space-time relationality within teaching/learning situations was evidenced in formative assessment responses (on the parts of students and teachers) in the latter student learning artifacts collected as the unit of study in Year 2 came to a close. These latter artifacts began to take on a rhythmic character in Phase III. The rhythm was marked by unique emphases and patterns fleshed out over time revealing repetition of ideas, practices, and understandings. But, it was a repetition that was very tentative. Repetition is a notion that Risser (1997, p. 34) traces back to Aristotle (1925). Repetition is discussed as a `turn and re-turn to self understandings, acting on possibilities. Risser explains that in "this temporal movement of the self toward its future possibilities, one recommits oneself to the possibilities that are recognized as one's own"...where "past possibilities of action become future possibilities and are repeated in the moment of decision" (p.38). Thus, Risser concludes that repetition is "fundamentally dynamic"(p. 39). We could distinguish dynamic repetition (creative and life giving) from static repetition (repeating the same) in our

examination of the artifacts. It was dynamic repetition that needed to become the central interpretive task of formative assessment. Students' tentative repetitive understandings needed to be validated and prompted. Students' tentative repetitive understandings entailed coming to understand differently, and thus concomitantly, creating and re-creating self-understandings. This repetitive movement was a continuous process of coming to see; a backward movement that re-covered and re-presented alongside a forward movement that generated and evoked. Dewey (1934) calls such ensuing rhythm, "esthetic recurrence"; relationships that sum up and carry forward (p.166). Dewey distinguishes esthetic recurrence from mechanical recurrence. Mechanical recurrence focuses on isolated parts and thus away from the whole. Esthetic recurrence, looks to the individuality present in each learning artifact seeking learning personal connections but also reaching out to the relations, associations, and interactions with other individuals, expanding the whole. Esthetic recurrence was what teachers gradually attended to, manifesting relationships rather than elements in learning artifacts recurring. These recurrences presented themselves in different contexts and with differing learning consequences so that every recurrence was "novel as well as a reminder" (Dewey, 1934, p. 169). This capacity to perceive relationships among parts was what teachers struggled to interpret and act on throughout the study.

Formative Assessment Artifacts as the Coherent Fabric

Seeking insights from our findings across the teachers' online logbook and students' formative assessment artifacts, it was clear the online logbook served as the site giving sight to the individual alongside the collective thinking movement of teachers/researchers attending to formative assessment processes in middle school science classrooms. Teachers gained teaching ideas from each other, grappling with assessment practices, and enlarging each other's understandings. Repetition of ideas, practices, and understandings permeated the online logbook documenting a movement of teachers repeatedly seeking out and seizing back possibilities for teaching and learning. As such, formative assessment understandings formed and reformed in relation to the act of teaching itself. All of us caught glimpses of formative assessment judgments holding the potential to restore the participatory dynamic integral to learning, taking life as a movement of thought for teachers and their students. But, these glimpses were not translating readily into formative assessment artifacts of student learning.

Over Year 1 our student formative assessment artifact collection exceeded 4000. The materials were recorded, analyzed, organized, and stored in file boxes distinguishing classrooms and students. Over Year 2 our student formative assessment artifact collection exceeded 3000. Once again the materials were recorded, analyzed, organized, and stored. Sidorkin's (2001) characterization of education as the production of useless things haunted our gaze as we attended to these artifacts in relation to the 2-year research process. Dewey (1938) explains that "an experience is always what it is because of a transaction taking place between an individual and what, at the time, constitutes his [sic]

environment...” (p. 41), thus, the conceptions of *situation* and *interaction* are inseparable. But, the majority of the collected learning artifacts did not matter because they were not the matter (the materials) of the intersections of the learning situation with students’ understandings. Acknowledging and using the meeting place of situation and interaction within formative assessments necessitates attending to space-time reciprocity. The online logbook articulated teachers increasingly valuing space-time relationships within teaching/learning for greater science inquiry. But, it was this meeting place of situation and interaction that student formative assessment artifacts needed to cohere. “Only when the constituent parts of a whole have the unique end of contributing to the consummation of a conscious experience, do design and shape lose superimposed character and become form” (Dewey, 1934, p. 117). Such form was not necessarily found in the artifacts labeled formative assessments. It seemed formative assessment artifacts were destined to failure if they served a specialized purpose distinct from the learning experience created in the classroom.

Despite the deliberate design by participating teachers to shape and live the terms of inquiry in their science classrooms, formative assessments remained a hurdle that some boldly attempted and others retreated away from. The courage it took to commit fully to formative assessment artifacts as mediums, embracing learning process within learning products, were definitely taken up by all participating teachers as risks for themselves and their students in terms of being able to account for learning via criterion reference tests and other system mandated procedures. Dewey (1934) clarifies that a medium is a “go-between” (p.198). The interpretive eye entailed within the dynamics of formative assessments demanded that teachers respond with “sensitivity to a medium as a medium” as the “heart of all artistic creation and esthetic perception” (p.199). Everything depended on the teachers’ surrender to learning process, attuned to the ways in which the materials of situation and interaction were seen and acted upon when operated as a medium. Formative assessments needed to be perceived by teachers as the “coherent fabric” expressing the go-between of student and subject matter. Dewey (1910/1978) relays how the inquiry process assumes that we enter into an inquiry as inquirers, acting as thinkers positioned by the terms and conditions of an inquiry contract, and that what emerges must weave into a “coherent fabric”. But, teachers’ capacities to surrender ranged considerably. The online logbook demonstrated that perception heightens teacher sensitivity to forming and reforming learning. Such sensitivity heightened awareness to building relations between students and subject matter. Awareness increased attention to not only what is, but to the possibilities of what could be. But, a confidence to act on this awareness was desperately lacking in teachers’ experiences. Perhaps it was never there, or perhaps confidence was stripped bit by bit over years of experiences, with teachers increasingly positioned to act more like technicians.

Conclusions

As we concluded our study we responded with delight in the observed and documented enhanced visions and understandings of teachers' forming and reforming roles within teaching and learning. Concomitantly, we also responded with disappointment, as the student learning artifacts revealed the smallest steps taken by teachers to attend to learning processes as huge leaps of faith for themselves. Teachers gained a language to see with, taking into account the relational intersections of every learning encounter. But, it seemed the power of this language needed to be exposed more fully, rendered visible and comprehensible repeatedly within the acts of teaching to evoke a teaching confidence in process that boldly persists, making it impossible to separate learning processes from learning products. Dewey (1916) insists that "A reorganization of education so that learning takes place in connection with the intelligent carrying forward of purposeful activity...is a slow work...but this is...a challenge to undertake the task of reorganization courageously and persistently" (p. 137). And, we will continue this slow work, but perhaps our study also called attention to the foreignness of artistry in all of our lives and the consequences of not engaging in the art alongside the science of learning/living.

We opened this article acknowledging that attention to the content of assessment products can thwart process and undermine the work of learning as a movement of thought. We found hope in this study that formative assessments can reveal the ensuing dynamic inherent to the creation of meaning, with teachers responding accordingly, forming and informing the educative movement. It was through purposefully attending to artistic teaching visions that an educative movement was prompted; a backward movement in search of expanded learning insights, kinship, and precedents, and forward into the creation of new meanings and relations. Assessment as a moving force became more difficult to betray. We conclude that learning processes and products must affirm and manifest the vitality of each other within formative assessments. To act in accordance with the dynamics of formative assessments it seems critical that educating teacher artistic vision must be cultivated and embraced.

Implications

Our study chronicled concrete use of formative assessments as a dialogic medium (Duschl and Gitomer, 1997) for educators to see and develop capacities connecting curriculum, teaching, and assessment, furthering the learning process in all learners over both years of the study. It was the notions of "medium" and "seeing" that needed to be better understood by all involved. Dialogic engagement between self (student/teacher) and other (subject matter) is integral to the relational reciprocity of much arts-based research intending to be a medium to understandings of self in the world (e.g. Barone, 2001; Barone & Eisner, 1997; Bresler, 2004; Irwin, 2004). We found arts-based educational research to offer much potential for enabling teachers to see/act within

teaching/learning situations, understanding formative assessments to be mediums for sense-making.

One potential was in elaborating a theoretical language with which teachers and researchers could articulate and imagine the process character underlying the creation of teacher and student work. This study elucidated for participants ways in which understandings form, adapt, and grow through attention to other(s). Arts-based educational research provided access to language and imagery expressing and valuing attention to learning processes and ensuing relational complexities.

A second potential was in drawing attention to the significant role of neglected epistemological considerations such as internalization, integration, self-identity, experimentation, observation, and time within the work of learning. This study contributes to an existing body of work foregrounding the underestimated impacts of these considerations on teachers and learners (e.g. Bresler, 2004; Greene, 2004; Irwin, 2004), providing concrete examples of the learning power within these epistemological considerations.

A third potential concerned enlarging teachers' understandings essential for establishing and sustaining inclusive science classrooms, preparing current and future science educators to meet a wide array of learning needs in the heterogeneous science-learning environment. This study made visible a process by which science educators explored, and came to see and account for student learning.

Underlying the potentials noted is the grounding of arts-based educational research in attending primarily to the given particularities within any situation as the necessary place to begin seeing (Barone & Eisner, 1997; Dewey, 1934; Macintyre Latta, 2005). Educating artistic visions most importantly assumes this starting place, orienting teaching and learning toward an ongoing forming/informing/reforming search. The given in participating science classrooms comprised the particularities of students, learning content and context, teacher, and all other contributing aspects gathering within specific teaching/learning situations. These givens comprised the raw materials of inquiry, alive in the students, teacher, and subject matter themselves. Teacher recognition of these raw materials and purposeful search for relationship building, connecting students, teacher, and subject matter was the work of inquiry. As these pedagogical relationships between students and subject matter emerged and developed the teacher's role was to enable learning in each student, fostering connections derived from an understanding of students and situation. Discerning these relationships was the indispensable condition of attending to the inquiry process. Inquiry, then, was a movement of thinking, a medium, in which meaning was not applied or imposed but manifested, and could never be fully anticipated. Increasingly, participating teachers understood that if teaching and learning evoked this "moving force" (Dewey, 1938, p. 38), formative assessments must affirm the uncertainties and possibilities that were at stake within the movement. Our attempts to do just that were evidenced through formative assessments becoming less about the constituents of the relationship (teacher, student, subject matter) and more about the

“relationality of the relationship” (Biesta, 2004, p.13). Teachers and students needed to embrace the space-time uncertainties and possibilities encountered as the sustenance furthering learning. To do so Dewey (1926) calls for “art in education and education in art” stating:

Art and aesthetic experience is what is missing, ‘art’ denoting any selective activity by which concrete things are arranged as to elicit attention to the distinctive values realizable by them. Aesthetic appreciation and art so conceived are not additions to the real world, much less luxuries. They represent the only ways in which the individualized elements in the world of nature and man [sic] are grasped. (p. 12)

Participating teachers began to artfully grasp formative assessment use within concrete science learning situations, linking process-product-learner. As Dewey (1926) and Eisner (2004) have argued for some time, education has much to learn from the arts about the practice of education. We saw tremendous professional development potential for teachers and students through formative assessment practices experienced as artful mediums fostering learning connections across all disciplines and subject matter. Dewey (1910/1978) notes that “the teacher’s own claim to rank as an artist is measured by his [sic] ability to foster the attitude of the artist in those who study with him [sic]” (p. 288). Educating artistic teaching visions became the responsibility of teachers to the work of learning, entailing an obligation to the future, to generativity, to the unanticipated. Our study told us developing this capacity was critical to the formative assessment process for all learning. Arts based educational research and researchers have important leadership roles to assume in making visible and tangible the necessary learning conditions. Our collective efforts toward educating artistic visions stirred the artistry of teaching and learning within teaching identities. But, we are not fully awake yet; ready to awaken the artist within each student.

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