Working within the Zone of Proximal Development: Formative Assessment as Professional Development

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Introduction

Professional development efforts in science education have often emphasized the workshop experience, where teachers learn new skills in order to infuse their practice with current thinking. These "one size fits all" (Ball & Cohen, 1999) experiences seldom are situated within an ongoing context of professional practice. Ball and Cohen suggest that teacher learning is often seen as "either something that happens as a matter of course from experience or as a product of training in a particular methodology or curriculum" (p.4). They further argue that we need "carefully constructed and empirically validated theories of teacher learning that could inform teacher education, in roughly the same way that cognitive psychology has begun to inform the education of school children" (p. 4).

In this paper, using a Vygotskian theoretical framework and the zone of proximal development (zpd) as a core feature, we take the view that teachers who strategically and intentionally participate in formative assessment practices can undergo profound transformation in their professional growth. We argue that formative assessment involves individual and mutual participatory appropriation of learning products (Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1993; Griffin, Newman, & Cole, 1989; Hickey, 2001; Moschkovich, 1989) as part of joint productive activity (Tharp & Gallimore, 1989) within the zone of proximal development (Vygotsky, 1934/1986). We propose a trajectory of teacher development as support for this claim, and present as evidence two case stories, taken from different geographies and contexts.

Understanding teaching as mutual transformation demands a rich, powerful theoretical framework. The approach offered by Vygotsky (1934/1986) and by subsequent researchers who rely on Vygotsky (Brown, 1992; Brown & Campione, 1992; Rogoff, 1995, 1998; Jones, Rua & Carter, 1998; Tharp & Gallimore, 1989; Wells, 1999) views learning and teaching as a sociocultural process in which the interaction between the participants is the focus. Vygotsky considered the teacher-student relationship transformative for both students and teachers (Rogoff, 1995, 2001; Tharp & Gallimore, 1989; Wells, 1999) but was concerned more with the activities of the learner in joint interactions.

Formative assessment, also called assessment to assist learning, has gained much attention over the past decade, especially since the publication of Black &

William's influential article on the 'black box of assessment' (1998) revealed that classroom-based formative assessment, when appropriately used, can positively affect learning (Black & Wiliam, 1998; Harlen, et al 1999). This past research has provided a clear indication that "using [formative] assessment … does indeed improve learning and raise standards of students' achievement. (Harlen , 2000, p. 3). Most formative assessment research has focused specifically on student gains, rather than on teacher learning. In this paper we focus specifically on teacher transformation that occurred as they engaged in formative assessment with students, taking the perspective that interactions between teacher and learner are reciprocal. Tharp & Gallimore (1989) suggested that "Assistance most often flows from the more competent to the less competent participant - from teacher to learner, from trainer to trainee -but influence, a more general concept, is inevitably reciprocal and shared" (p. 89).

Research by Jones, Rua & Carter (1998) has suggested that in mentor-novice teacher dyads "not only did the less experienced teachers learn from the more experienced one but the expert also learned from the novice" (p. 982). Achinstein and Villar (2002, p. 18) at the New Teacher Center at the University of California, Santa Cruz, suggest also that the relationship between mentor teacher and new teacher works best when it is reciprocal, saying that "the two are involved in co-construction of knowledge, co-exploration, problem solving and critique of their work" (Achinstein & Villar, 2002, p. 18).

Taken together, this prior research suggests that experienced teachers are transformed as they participate with students and with novice teachers in joint productive activity. The question we ask in this research, is: If teachers are transformed as they use formative assessment, in what way and under what conditions does this happen and how can we characterize this transformation?

One lens for viewing transformation relies on understanding the ways people's participation changes over time, as they are jointly engaged in teaching and learning. Transformation of participation implies that "what people learn is a function of their transforming roles and understanding in the activities in which they participate" (Rogoff, 1994, p. 1). Rogoff is clear that participatory appropriation is the mutual constitution of personal, interpersonal and cultural processes (Rogoff, 1995, p. 156). She states that "the participatory perspective focuses instead [in contrast an internalization model] on events as dynamically changing, with people participating with others in coherent events (where one can examine each other person's contributions as they relate to each other, but not define them separately), and [where] development is seen as transformation (Rogoff, 1995, p. 156-157).

In this paper we assume that formative assessment involves mutually interactive participation between teachers and students, as described by Rogoff, and as part of joint productive activity (Tharp & Gallimore, 1989). And, we argue that the transformative participation occurs within the zone of proximal development. We label these complex interactions 'working within the zone of proximal development', and we view teachers and learners as participating in a mutual dance of appropriation of ideas and actions (Brown, et. al., 1993). We draw upon others' theories of appropriation (Brown, et. al., 1993; Griffin, Newman, & Cole, 1989; Hickey, 2001;Moschkovich, 1989), all of whom support a reciprocal view of learning

and teaching in their research.

As evidence for transformation we describe the participation of two different groups of teachers, one each in California and Pennsylvania, who used formative assessment as part of an inquiry in elementary classroom settings. Both were informed by the same theoretical and methodological perspectives. The research occurred on two levels simultaneously. At the first level, teachers used formative assessment to guide learner growth, (in the California case, working with elementary students on science inquiry investigations and, in the Pennsylvania case, mentoring new teachers in using science inquiry). At the second level, our primary research focus, the teachers developed a deeper understanding of their own teaching practices.

We present evidence that both groups of teacher/experts changed as part of engaged participation (Hickey, 2001) in mutually defined tasks. Both used scaffolding tools (rubrics) designed specifically to mediate understanding with learners. Vygotsky was explicit on the use of mediating tools, which can be signs or symbols, language or alphabet, beliefs or concepts acting within the zone of proximal development. These "tools are artificially created stimuli that influence the behavior of oneself and others" (Jones, & Carter, 1998, p. 968). Vygotsky talked primarily about symbolic tools, but they can also be thought of as the physical tools of science (Newman, et al, 1989).

We conducted research in two geographical areas using related but different focuses. At the Exploratorium (CA), Ash focused on the work of two elementary teachers engaged in classroom-based research using students' inquiry-related questions (van Zee, Iwasyk, Kurose, Simpson & Wild, 1997) as formative assessment. The solicitation and examination of student questions and their subsequent work towards independent inquiry became a vehicle for formative assessment, joint productive activity, and self-examination and reflection for both the students and their teachers. Teachers used a scaffolding tool (Figure 1), a questioning rubric adapted from Harlen (1998).

As part of her work with student teachers and mentor teachers, Levitt explored the professional growth of both the teacher candidate and the mentor teacher as they participated in a learning group designed to teach and subsequently endorse new teachers' skills and competencies in the teaching of inquiry science. The Inquiry Science Endorsement (ISE) (Appendix A) became a vehicle for ongoing, developmental formative assessment, joint productive activity, learning conversations, and self-examination for both the teacher candidate and the mentor teacher.

Theoretical Underpinnings

In this section, we discuss how several previously established theoretical perspectives form the framework underlying this research. These theoretical areas include the zone of proximal development, individual and mutual participatory appropriation of learning products, joint productive activity, and formative assessment. Out of this we created a proposed trajectory of teacher developmental growth grounded in these theoretical perspectives and based on research with classroom teachers.

Categories of learners' questions				
Comments	**Philosophical**	**Factual**	**Complex**	**Investigable**
Actions by teacher can include:				
Acknowledge	Ask more about what the question really means	Can child answer with reference	Focus on the part that can be done	Discuss how to do this
How to make into question	Does it become a question?	Give answer or find it	Consider variables Break it down to simpler questions	Can it be done now?

Figure 1. *A categorization of the kinds of questions children ask and a flow chart for handling questions. Adapted from Harlen 1998, p.114. Original is more extensive.*

The Zone of Proximal Development and Appropriation

According to Vygotsky, the zone of proximal development (zpd) is "the region of activity that learners can navigate with aid from a supporting context, including but not limited to people" (Vygotsky, 1934/86; Brown, Ash, Nakagawa, Gordon, Rutherford & Campione, 1993, p. 5). The zone of proximal development embodies an emphasis on readiness to learn, "where upper boundaries are seen not as immutable but as constantly changing with the learner's increasing independent competence at each successive level" (Brown et al, 1993 p. 35). "This process begins with the adult at first doing most of the cognitive work. This phase is followed by one in which the adult and child share responsibility. Finally, the child is able to perform independently" (Brown, Ellery, & Campione, 1996, p 8).

Brown and Ferrara (1985) argue that instruction needs to be aimed at the upper boundaries of a learner's zone and that by doing so, "the student is led to levels of success previously not envisaged by neither the student or the teacher" (p. 302). The scaffolding is gradual, as the teacher regulates the interaction within the child's zone, until the child can complete the task independently of the teacher:

> *… with regards to instruction, Vygotsky believed that in most settings adults and children work together to bring the child from his or her initial level of mastery gradually to the most advanced level of independent activity that the child can achieve…(Campione, Brown, Ferrara & Bryant, 1985, p. 77).*

One way to look at formative assessment interactions between teacher and learner is to view their activity as ongoing participatory appropriation (Rogoff, 1995) of each other's ideas and activities in a co-constructed zpd. Newman et al, (1989) have characterized appropriation as a two way process, emphasizing that neither the teacher nor student have a complete understanding of the interaction occurring between them:

> *In constructing the zpd for a particular task the teacher incorporates children's action but neither own the system of activity…Just as the children do not have to know the full cultural analysis of a tool to begin using it, the teacher does not have to have a complete analysis of the children's understanding of the situation. (pp. 63-64)*

Vygotskian scholars would argue that both teacher and learner work together to bring the learner from her initial level of mastery to gradual independent activity, *and* that together they bring the teacher to greater expertise, so that they can be of utmost assistance. In a co-constructed zpd, participatory appropriation can apply to both learner and/or teacher because of the ongoing and changing interpretation of each other's ideas and actions. Thus, both the learner and the expert appropriate cognitive products (a statement, tangible product or an action) but use it in different ways, which may not always have been the one intended (Moschkovich, 2001). Moschkovich (2001) talks about expert (teacher) and learner (student) appropriation in the following way:

> *Expert and learner appropriation share central characteristics. Both expert appropriation and learner appropriation involve joint productive activity, developing shared attention and meanings, and taking another's product for one's own use. This "taking for one's own use" involves both interpreting a product within one's own knowledge system and using the product based on this interpretation. Taking these common features, I define appropriation in general as taking the product of joint activity for one's own use. (p. 8).*

Moschkovich (2001) argues that appropriation is usually more intentional for the expert than for the learner, because the expert has more complex domain knowledge. During expert appropriation, "the expert interprets the student's cognitive product within his or her knowledge framework and subsequently engages the student in an activity reflecting this expert understanding of the situation" (Moschkovich, 2001, p. 6). For the learner, the appropriation consists of acquiring knowledge, skills and/or strategies that help in moving towards upper levels of competence. While the learner gains knowledge (understanding) of the content and structure of a discipline (i.e. mathematics, writing, science, etc.), the expert, in turn, makes advances in the ability to structure content, as well increase the skills and strategies that make up pedagogical content knowledge (Shulman, 1989; Van Driel, Verloop, & de Vos, 1998). This can only be accomplished by appropriating

each other's products.

When appropriation is reciprocal or multidirectional, the term mutual appropriation can be used (Griffin, Newman & Cole, 1989; Moschkovich, 1989) to describe how teachers and learners together participate in the teaching/learning process. Thus the same material might be appropriated by both the learner and the teacher, but used in different ways. If joint activity is productive, one can argue that the goals of the teacher and the learner move closer together. In the research described in this paper, we rely on using formative assessment as the focus of joint productive activity; knowing that current levels of participation in formative assessment, and appropriation of knowledge change future participation, so that "both the purposes and the means of joint action are themselves constantly undergoing transformation" (Wells, 1999, p. 324).

Formative Assessment as Joint Productive Activity in the ZPD

Formative assessment can take a wide variety of forms and structures, for example for soliciting learning products, the rubrics used for evaluation, and in the manner in which feedback is given to the learner. One interpretation of a formative assessment learning/teaching cycle is offered in Figure 2, taken from Harlen, Ash, Bartels, Rankin, Bevan, Tucker, Ebisusaki & Kanevsky (2000). This iterative cycle illustrates how teachers gather evidence during student activities, evaluate the evidence, and determine the next steps in order to help move the student to a higher level of understanding. In the language of joint productive activity or participatory appropriation, we would say that the teachers appropriate the products of the learners (evidence) in order to analyze these and to consider next steps; while the learners appropriate the strategies and structures (next steps) of the teachers in order to provide new products (more evidence) for continued analysis. At each stage, there is opportunity for variation in practice. For example, while one teacher may rely on learners' written products, such drawings or writing, another may document student questions or explanations, while another might watch the learner in action. Some teachers use portfolio assessment to capture students' best work, while others might invite individual interviews. All fall within the broad practice of formative assessment (Ash et al, 2000).

The cyclic determination of differences between teacher and learner understanding can be interpreted as an ongoing diagnosis of the distance between the learner's current and potential levels of ability in the zpd. As the teacher collects evidence of learner understanding, she appropriates products that reveal needs and strengths. In order to interpret the evidence, the teacher compares her original expectations against the actual performance of the learner. In order to assess evidence for understanding and act on that knowledge, the teacher must appropriate the student's understanding into her own system of understanding, compare the two understandings, and then decide how to guide the student within the zpd. We call this 'working within the zpd.'

It seems clear that both expert and learner appropriation occur in these instances but can we say that mutual appropriation is occurring? Mutual appropriation

involves both expert and learner appropriations. The essence of this argument involves cyclic appropriation and iterative use of another's products. This description is virtually identical to the formative assessment cycle already described as Figure 2. For the teacher, it includes appropriation of student product such as questions or drawings; for the student, it is learner appropriation of teacher strategies, questions or activities.
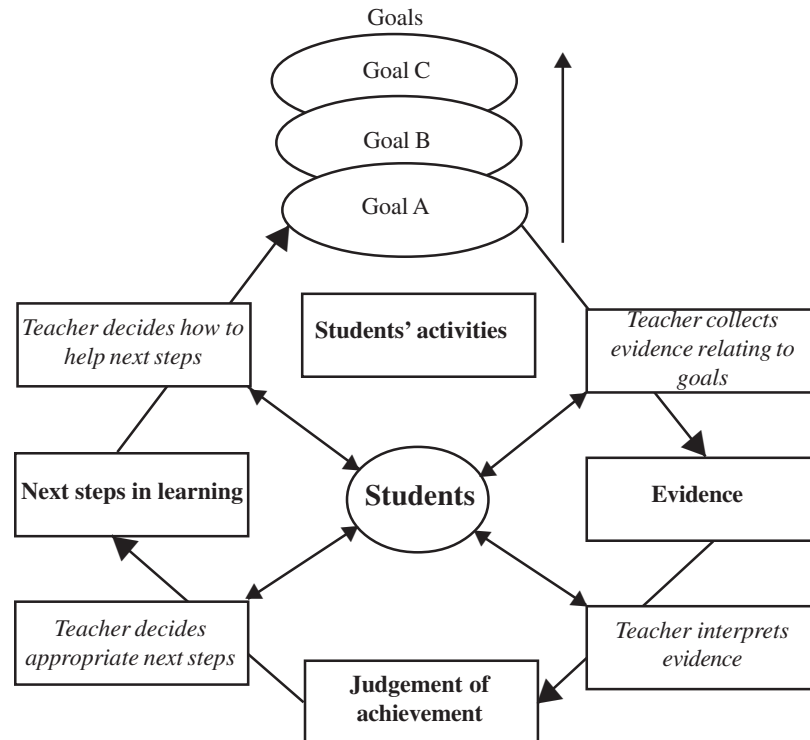

Figure 2. *Cycle of formative assessment adatped from Harlen, et al (2000).*

A Proposed Trajectory of Teacher Change

We have outlined a proposed developmental trajectory of teacher transformation (see Figure 3). In proposing the trajectory, we synthesize others interpretations of mutual appropriation, Tharp & Gallimore's view of joint productive activity, and Harlen's interpretation of formative assessment, within the Vygotksian zone of proximal development. The four steps of the proposed trajectory are:

1. ***Teachers examine student work closely, using a prescribed scaffolding tool, i.e. a rubric, as a guideline. Often, this is done in collaboration with other teachers.***

Teachers start by examining student work, setting the stage for analyzing the kinds of thinking that may have gone into their production. This often leads to categorization of learner products. Student work may include students' questions, drawings, utterances, writings, presentation, etc. It also involves advancing the teachers' own understanding of the task with respect to expectation or goal, based on the scaffolding tool. Typically, the teachers have in mind a set of strategies for advancing learners' understanding.

Teachers examine student work closely, using a prescribed scaffolding tool, i.e. a rubric, as a guideline. Often, this is done in collaboration with other teachers.

Teachers begin to see a mismatch (using the scaffolding tool) between their expectation and student level of performance, either in competence, proficiency, ability or overall goals.

Teachers self-reflect, observe their own practice, and begin to adjust pedagogy, either by changing the requirements of the task, by providing specific student guidance, or by reevaluating the goals of the task.

Teachers continue to self-reflect and adjust or constrain tasks and/or expectations according to the student's ability. This helps students move towards desired conceptual goals, but also moves the teachers toward increasing sophistication in diagnosing and understanding their own pedagogy.

Figure 3. *A proposed trajectory of teacher change.*

2. *Teachers begin to see a mismatch (using the scaffolding tool) between their expectation and student level of performance, either in competence, proficiency, ability or overall goals.*

Using a scaffolding tool, the teachers begin to examine the learners' evidence, and to evaluate the mismatch between their expectations (goals) and student's performance. Noticing that there is a difference or mismatch in the expected and actual outcomes can cause teachers to re-evaluate their own structures for teaching or particular content areas, strategies or specific learning tools. Teachers begin to think of effective means of instruction to mitigate the differences. Although teachers may start with prescribed scaffolding tools, invariably these are re-evaluated in the closer context of student work.

3. *Teachers self-reflect, observe their own practice, and begin to adjust pedagogy, either by changing the requirements of the task, by providing specific student guidance, or by reevaluating the goals of the task.*

During this step, teachers question the scaffolding tools, and their own goals, more explicitly in order to more accurately reflect learners' understanding. If the tools are inadequate, then teachers can readjust the goals of the task in a variety of

ways. They can modify the criteria for decision-making based on current understanding of learner's products and the mismatch described in step 2, or they may clarify or reify the scaffolding tool itself, typically making these decisions public to learners. Teachers sort or select strategies that can take learners to new levels of understanding. This requires a degree of questioning (of the self and others) to ascertain the appropriate next steps and perhaps even abandoning or revising preconceived ideas that teachers held when initially examining student work (step 1).

4. ***Teachers continue to self-reflect and adjust or constrain tasks and/or expectations according to the student's ability. This helps students move towards desired conceptual goals, but also moves the teachers toward increasing sophistication in diagnosing and understanding their own pedagogy.***

In this last stage, the teachers are increasingly aware of the changes they have had to make while using the formative assessment cycle. They are able to reflect on their own processes and the products that were most useful in the participation with learners. The examination of evidence and the actions taken to mitigate differences in individual or joint understanding result in transformation for the teachers.

Data and Methodology

Two different studies inform this research. The first case investigated the work of two teachers who participated in a teacher research group in California. The teacher research group focused on using formative assessment in guiding student science inquiries, with an emphasis on investigable questions. The second case examined the relationship between a mentor teacher and a teacher candidate in Pennsylvania. The focus was on using formative assessment of the pedagogical skills of the teacher candidate in order to guide her toward the use of classroom science inquiry.

Each of the authors has a long-standing relationship with the participating teacher research groups. For this research, each collected ethnographic field notes, conducted interviews with teachers, and regularly attended teacher research groups in professional development sessions aimed at understanding teacher research and formative assessment. Beyond that, direct experience with actual teacher professional practice was obtained through in-class visits. Teacher interviews were tape recorded and transcribed. Researchers acted as participant observers in teacher research.

Transcripts from learning group meetings were coded and categorized until patterns emerged forming the basis for the steps in the trajectory. The proposed trajectory was then utilized as a framework for analyzing the particular interviews described in this research. Case descriptions were shown to the teachers to check for agreement of the portrayal of their developmental growth though the use of formative assessment.

The California Case

At the Exploratorium in California,

…teachers do the research, form the questions, gather and interpret the data, and then use results to change their own practices. This formative assessment of their own methodologies—using student work as a focus—is part of a continuous feedback loop that allows children's learning and inquiry to be the core element around which changing practice is informed. (Ash, Greene, & Austin, 2000, p. 1)

Over the course of 4 years, 12 teacher-researchers were actively engaged in the annual teacher research group. The learning group met monthly throughout the school year, not including two research release-days per teacher (Ash & Greene & Austin, 2000). The case study for this paper is based on a subset of two teachers, with one highlighted. All learning group teachers examined students' work closely, in particular students' skill in asking questions that might lead to inquiry. All teachers systematically collected and observed student questions, categorized questions publicly with students, and then introduced a strategy for selecting questions that helped move inquiry forward. One scaffolding tool (Figure 1), based on the questioning rubric outlined by Harlen, (1998), focuses on five categories of questions—comments as questions, philosophical questions, factual questions, complex questions and investigable questions, questions which can lead to investigation by children (Harlen, 1998). This tool was used most extensively by teachers. Using the rubric typically involved the public sorting and discussion of the questions with the children and subsequent collaboration towards making the potentially investigable questions more investigable, more specifically, questions that can lead to inquiry investigations by children in the classroom.

Wendy, the primary focus of the California case, was part of the teacher research group at the Exploratorium for four years (Cheong, 2000). She is representative in that her professional growth paralleled her use of questioning with students. Wendy had previously participated in several professional development opportunities at the Exploratorium, including two week-long inquiry and formative assessment institutes. She started teaching in a second grade classroom, and later taught first grade, both at a mid-size urban school in San Francisco, a school that included many second language learners. The San Francisco Unified School District has been involved in science education reform for many years.

She focused on both her own and her students' use of questioning in her classroom, at first using a kit-based sound unit as a vehicle for inquiry investigations. She began by formatively assessing children's questions in order to explore their understanding of both scientific concepts and the processes of inquiry (observing, predicting, etc). Later she studied her own use of questions as a way of eliciting their understandings more strategically and efficiently. The collaborative evaluation of student questions with her students allowed her to focus on their questions in new ways. As she became more facile at asking and framing questions of the

students, so, too, did her students become more able to frame their own questions as both moved towards deeper investigations.

The Pennsylvania Case

In a separate context, Levitt collaborated with mentor teachers and teacher candidates engaged in formative assessment of the development of teaching skills of inquiry specifically concentrating on five specific skill and knowledge areas. Collaboration between the teacher candidates and their mentor deepened all teachers' understanding and practices of inquiry in the classroom.

During the 1999/2000 school year, thirteen teacher candidates and their mentor teachers participated in a field test for an Inquiry Science Endorsement for the teacher candidates. The Inquiry Science Endorsement (ISE—ASSET, 2000), although initially designed to summatively assess the teacher candidate's competence, eventually became a vehicle for ongoing, developmental formative assessment of these skills for the teacher candidate. Mentor teachers examined the teacher candidate's teaching skills closely. The mentor teacher carefully observed the teacher candidate's teaching performance, recording evidence of achievement of a specific skill, then subsequently analyzed the teacher candidate's skills using the ISE as an assessment tool (see Figure 2). The teacher candidates and the mentor teachers participated jointly in a learning group to discuss and deepen their understanding of the interpretation and implementation of the skills of inquiry in an elementary classroom. The learning group met monthly throughout the school year. This case focuses on the relationship of one particular mentor teacher (Barb) and teacher candidate pair.

Barb has over 17 years of teaching experience. At the time of her participation as a mentor teacher in the learning group, Barb was teaching fourth grade. Previously, she had participated for several years in a teacher learning group that focused on implementing inquiry in the elementary classroom. This particular year, the group expanded to having individual teacher candidates paired with a mentor teacher. The group focused on using the ISE guide as a tool for deepening their understanding of implementing inquiry science in the classroom. Ultimately, the goal of the group was to recommend changes in the skills and competencies described in the ISE, based on their actual paired work in the classroom. Barb's involvement in the learning group came through her connection to an LSC (Local Systemic Change) targeting the reform of elementary science education. Through this LSC she had provided professional development instruction for teachers as well as participated in professional development designed to increase the effectiveness of her own teaching of inquiry. To this end, she participated in the Institute for Inquiry (at the Exploratorium, San Francisco, CA), and served as staff on a local adaptation of this Institute held annually for the LSC.

Using the ISE guide, Barb determined the gap between the expected outcome (the skill as described in the ISE) and the actual teaching performance of the teacher candidate in order to determine which next steps would most assist in the development of her skills from their current level to an upper level of competence. Often, these gaps between expected and actual performance were discussed in the

learning group to gain a better understanding of the nature of the skill and its implementation in the classroom. Together, each mentor teacher and teacher candidate pair would discuss a plan for improvement. The formative assessment process caused the mentor teachers to reflect on their own skills of teaching through inquiry to recall specific episodes that could be used as demonstrations of a skill for the teacher candidate or to decide on a strategy for demonstrating a skill for the teacher candidate.

Two Case Stories of Teacher Transformation

In the following pages, we describe in greater detail how the two different cases follow the proposed trajectory of professional transformation.

Step 1. Teachers examine student work closely, using a prescribed scaffolding tool, i.e. a rubric, as a guideline. Often, this is done in collaboration with other teachers.

In California, Wendy started by using active listening to better understand students' scientific thinking.

I practice active listening to the children's responses, since their questions often come in the form of statements. Then it's up to me, the teacher, to help turn their statements into investigation questions by asking things like "Do you mean...?" or "Is this what you are asking?" I acknowledge and record all of their questions.

Her aim was to specifically examine their questions. Initially, she used the Harlen questioning taxonomy as a general template. When discussing questions with students, she focused on formatively assessing their questions, since her primary goal was to facilitate them frame questions in the investigable category—that is, questions that will move towards investigation.

Because questions can be investigable without being interesting or complex, this teacher and her students added complexity as a criterion to the investigable questions in order to help their movement towards more complex questions. Most teachers who work with questioning agree that it takes active listening to hear the students' questions. Yet, active listening relies on knowing where children start and where they can proceed and it also relies on expert appropriation of some of the learner's questions and helping them move towards more productive areas. Wendy said:

…While watching the children explore, I encourage them to ask questions about whatever seems curious to them. Because students often have difficulty asking questions, I support them in various ways. For example, I do a lot of modeling. I also ask a lot of open-ended questions, such as: "Can you tell me what you are trying to find out with this instrument?" or "Is that what you expected to hear?" Eventually, the children get used to hearing the kinds of questions that can lead to investigations.

She routinely captured all questions on paper but did not stop there. She discussed the questions with the students, and together they selected the best examples. They grouped questions that belonged together and then combined them to create more interesting inquiries. Increasingly, Wendy revealed a greater capacity to listen to what children meant, to formatively assess the gist of children's thinking when they framed questions, so that she became more able to think of ways to help them express their ideas. Wendy talked about her increased capacity for listening and moving students to a higher level of questioning. One can say that the students and the teacher mutually appropriated the questions and the categories.

Applying the trajectory to the mentor teacher/teacher candidate relationship reveals similar patterns of action. At the beginning of the semester, Barb, the mentor teacher, discussed each skill in the ISE with the teacher candidate in order to come to a mutual understanding of that skill and to recognize the related criteria for achieving mastery. She began the process of assessing the teacher candidate's skills by observing her teach and carefully keeping an anecdotal record of each teaching episode. Initially, Barb observed the teacher candidate's overall teaching ability in science while using the ISE as a basis for her thoughtful analysis of the teacher candidate's practice. According to Barb,

The Inquiry Science Endorsement serves as a neutrally agreed upon set of standards and validates the important skills of inquiry. At the same time, the teacher candidate's comfort with the skills is increased because "others" [not the mentor teacher] have determined them. I observe [the teacher candidate] for the general teaching skills, but focus on the skills as described in the Endorsement. Because we had talked about these skills prior to teaching, we have agreed on what the skills might look like when actually used. When I have observed other student teachers, I have not necessarily had such a specific tool to help me assess their strengths and weaknesses to provide feedback for improving their teaching. My strategy had typically been to teach the lesson providing a model of general teaching skills. I didn't used to think about breaking down the lessons into specific skills for examining.

After the lesson, Barb and the teacher candidate discussed the lesson, providing opportunities for the teacher candidate to examine and reflect on her own teaching. When the teacher candidate then taught a lesson, she felt her lessons flowed "more smoothly" and that she knew "this is what I have to do and what I have to do next", because the skill had been discussed and the noticeable gaps related to specific established criteria that provided her with a framework for her lesson. Ultimately, the teacher candidate believed she was more "in tune" to the different skills necessary for teaching through inquiry because Barb modeled the expected specific skill in her own teaching. This grounded the teacher candidate's growth in the actual events of teaching. The formative assessment that occurred in the context of the ISE made the teacher candidate, as well as the mentor teacher, more aware of their identifiable practices and enabled both of them to extend their understanding of their practices.

One can say that they mutually appropriated the skills in question.

Step 2 . Teachers begin to see a mismatch (using the scaffolding tool) between their expectation and student level of performance, either in competence, proficiency, ability or overall goals.

At this stage in the process, teachers began to see the gap between learners' understandings and teachers' expectation, either in ability or overall goals. For example, as Wendy observed students' ability to raise questions, inevitably she found ways to assess the questions in order to devise a way to improve their development. Wendy said

I always start by modeling how to ask questions that can be investigated, and how to look at a list of questions and eliminate some or re-word some that can't be investigated easily. By inviting students into the process of recognizing questions that can be investigated, I found that I help them to be better questioners, yet to also do investigations based on their questions and get to the content I am responsible to teach.

In this statement, the teacher recognizes that there are different kinds of questions and that her job is to build children' understanding of the same. However, it is not enough to just get the questions out, meaning to simply brainstorm them, even if that is an important step in the process. A second teacher who relied on student questions, Judy, said at this stage:

… I have found that it is highly successful to post [these] questions on the classroom walls with sentence strips throughout the unit of study. This provides a continual discussion of unanswered questions that the students know they will have the opportunity to explore. Children can be taught questioning strategies. Many enjoy the challenge of brainstorming, refining, and working with questions as they picture themselves doing the investigation. Those who are able to grasp this process provide help for those who are at a more elementary stage of questioning.

Also at this stage teachers reflect on their prior work, specifically their prior practice of moving through lesson plans without formatively assessing or reflecting on what students really want to know. They understand that questioning as formative assessment provides powerful information regarding what the students want to know but more importantly what they still do not understand. This allows for important feedback for lesson design. More importantly it tells the teacher what strategies may not have been working, which allows them to reflect on their own teaching and to attempt to close up the gap between their original intentions and the students' understandings. In Wendy's words,

I did not always realize the power of questioning. These days, I see myself as a guide that helps the children scaffold, re-word, and constrain their questions, to help move them towards knowing how to do independent investigations.

In the mentoring case, similarly, as a result of the observation and subsequent discussion, the mentor teacher and the teacher candidate began to see the gap between the teacher candidate's performance and the expected outcome as outlined in the criteria of the ISE, either in proficiency, ability or overall goals. For example, Implementing an Inquiry Lesson is one of the five skill areas in the ISE. Within this skill, several of the criteria include the use of questioning as a strategy consistent with the use of inquiry. Evidence that the student teacher has mastered the skill includes posing questions and using open-ended questions to assess and further student understanding. In reflecting on several of the teacher candidate's lessons, Barb determined,

[The teacher candidate] was not yet demonstrating competence in this area. Primarily, she was using closed questions that only required single-word answers and she did not ask questions that encouraged students to think.

Barb felt strongly that the teacher candidate was capable of exhibiting this skill as she had demonstrated strengths in her general teaching abilities and had been receptive to integrating feedback into her teaching practice. Barb thought that perhaps the teacher candidate had not yet observed this skill implemented in a classroom or had not been exposed to these types of questions during her teacher education program, so she modelled them and explained them as part of this modelling process.

Step 3. Teachers self-reflect, observe their own practice, and begin to adjust pedagogy, either by changing the requirements of the task, by providing specific student guidance, or by reevaluating the goals of the task.

As their assessment of students' understanding increased, teachers began to match next steps to their students' perceived needs in a formal and explicit way. Wendy said,

I see myself …helping the children scaffold, moving from [a] more teacher-directed kind of science learning experiences to being able to start and do more of an independent investigation. I am definitely at this intermediate stage of transition…to [help] them [in] owning the questions, learning how to question themselves, taking a look and reflect[ing] on their own practices as they do their investigations …

A second teacher said,

… First, I model the process of selecting an exploration, turning it into an investigable question, designing the experiment, and developing a list of materials needed. Throughout this process, many scientific attitudes are discussed, such as flexibility in the process of the investigation, what constitutes success, how scientists work together, share data, and interpret results. It is also during this stage that I share how I will assess the students' investigations. Some of these assessments take the form of rubrics, checklists, required elements, and point systems.

Both of these teachers implied that they had in fact appropriated the students' questions, were able to measure their potential against a rubric that allowed them to guide student questions towards investigations and to select those that were more likely to 'pay off'. This was done in conjunction with the students because, in the end, the student needs to do the experiment, not the teacher.

In the case of the mentor teacher, it was important to discuss each skill in the ISE with the teacher candidate, to come to a mutual understanding of the skill, and the related criteria for achieving mastery. These discussions, along with input from the learning group, heightened Barb's awareness of each element of that skill area. After reviewing the document, Barb found that while she was teaching she might recognize a specific skill that had been discussed, and she then would stop in the middle of a lesson to point out how that particular skill had been demonstrated. Sometimes, Barb would pull the teacher candidate aside during the lesson to reflect on the teaching practice she had been demonstrating. Barb stated that she believed that participating in these conversations with the teacher candidate and modeling the skills "pushed buttons" in her own practice in areas that she may not have otherwise explored, thus causing her to reflect, and as a result develop these skills even further.

In addition, because the goals of the ISE were standardized for all the teacher candidates, the goals of the task could only be modified with group consensus. Therefore, the primary course of action for the mentor teacher was to adjust pedagogy and/or to use a different strategy for providing aid to the teacher candidate. This aid came in the form of very specific suggestions that helped the student teacher bridge the gap between her original skill level and the desired goal. For example, when modeling the skill of asking open-ended questions seemed not to help the teacher candidate's progress in her proficiency of this skill, Barb provided her with a written guide for developing specific types of questions. The guide provided question stems that the teacher candidate could use to plan the questions she might ask during her lesson. The teacher candidate used this guide as the next step in her development of this skill. The mentor teacher further adjusted her own pedagogy, deepening her own understanding of effective strategies for helping the teacher candidate.

The move from other-assisted to self-assisted for the teacher can occur when he or she relies less on the formalized practices set within the activities given in Figures 1 and Appendix A and becomes more able to internalize and use these step in a natural and less formulaic fashion. Again the teacher can begin to see that there

are ways to interpret student work that are more productive and strategic in guiding learners in the zpd.

> **Step 4. Teachers continue to self-reflect and adjust or constrain tasks and/or expectations according to the student's ability. This helps students move towards desired conceptual goals, but also moves the teachers toward increasing sophistication in diagnosing and understanding their own pedagogy.**

In this stage, teachers grow more explicit in their ability to help shape students' development. For example, teachers understood that they can constrain the task to maximize understanding in certain areas. The following is an example of such a constraint from Wendy's work.

> *Over the past year, I have come to see that if I limit or constrain the questions to a manageable number - like five or six - my students still maintain ownership over what they want to investigate, and we also move towards the content I want to cover. This intermediate step has been very helpful in getting me closer to my goal.*

> *When I started doing inquiry in my classroom, I accepted all questions the students asked, allowed them all to be investigated, and then had a discussion at the end. I found, however, that allowing children to do investigations based on all of their questions wasn't moving us toward the content, or some of the process skills that I wanted to teach.*

> *[Now] I add an intermediate step of grouping some of these questions because I know what concepts I need to teach. I work together with the students to re-word some of the questions so the students still have ownership over the questions they get to choose to investigate. We do this by doing a lesson on how to sort questions into different groups.*

Using questioning as the focus, teachers were increasingly able to diagnose their students' understanding and to move closer to providing the next steps to develop their own understanding.

> *Once I set up this climate in my classroom, that is how I plan to do the rest of my lessons or topics in science. …This way, children are more self-reflective when they ask questions. They know what questions are, which questions will lead them to doing tests, which question would be more like a reference kind of question, which questions we can easily answer with a yes or no, and which ones are maybe too big, because we don't have the materials or they seem too difficult unless we change it somehow.*

Similarly, the mentor teacher Barb began to constrain the task according to the

needs of the teacher candidate, which promoted defined growth in the teacher candidate. At the same time, Barb deepened her understanding and awareness of her teaching practices. Through joint reflection on the teacher candidate's lesson, Barb and the teacher candidate agreed that the teacher candidate needed to focus on and reexamine specific questions that would "open up" the lesson and move away from "dead end" questions, as Barb called them.

> *I became more aware of my own use of these questions and tried to increase the use of this type of question in my own teaching. As I asked the students more open-ended questions, I would stop and point them out to [the teacher candidate]. As she [the teacher candidate] continued to plan for the use of open-ended questions, and I modeled them more specifically, she [the teacher candidate] was able to better integrate these types of questions into her lessons and encourage more thoughtful participation from students through her developing skills.*

When asked about her professional growth in the process of helping the teacher candidate to open up the classroom to inquiry and advance her skills, Barb talked about her use of the assessment of the teacher candidate's skills to explore her own understanding of, and proficiency with, teaching through inquiry. She noticed that as she became more skilled at examining the practices of teaching through inquiry and engaging in dialogue with the teacher candidate, she brought her awareness of her skills to a more conscious level, so that they could also be examined and honed. So, as the teacher candidate became more able to self-assess her own progress toward these skills through examination and questioning of her practices, so did the mentor teacher, as they cooperatively moved their work towards the teaching of inquiry.

Discussion and Implications

Through two rich case stories, we have described teacher transformation as they participated in formative assessment with learners. We described these interactions as 'working within the zone of proximal development'. The development of each of the participants was accomplished through participatory appropriation of ideas and actions during ongoing formative assessment cycles of joint productive activity. For the learner, the appropriation consisted of acquiring concepts and strategies that guided them towards science inquiry, in the case of students towards performing their own investigations, in the case of new teachers, towards improving their teaching of inquiry.

Transformation for the learner was only one outcome of joint productive activity. The other outcome, the main focus of this research, was teacher transformation. Using Rogoff's (1995) transformation in participation model, the question became that of discerning how expert teacher participation was transformed. We now look at formative assessment and appropriation, first, in light of 'working in the zone of proximal development', and second, with respect to the scaffolding tools used by teachers. Last, we discuss the broader implications of this kind of research.

Working in the ZPD

We have made the argument that formative assessment involves mutual appropriation of products within the zone of proximal development. Another way of stating this is that transformation occurs as teachers and learners appropriated each other's thinking and actions, and as they understood better the meanings associated with them. While both the expert and the learner appropriate the same products, for example, the kinds of questions asked by learners, the expert and learner use the appropriated products in different ways.

In the two case studies, teachers became more adept at appropriating the learners' ways of thinking, their concepts, and their strategies, and then assessing their relevance, in order to select the most productive pedagogical strategy for moving the learner towards a goal that became mutual. Part of the power of using the zone of proximal development as a framework is that it encourages us to think in terms of a series of successive changes within an ever-changing zone of mutual understanding. While the particular focus of observation within the zpd can vary a great deal, as we have seen (in California, the focus was on students' questions, while in Pennsylvania, the focus was on novice teacher actions), in both locations, experts appropriated learners' products in increasingly sophisticated ways. The result for the expert was more effective ways of teaching.

The patterns seen in both cases studies exemplify the description given previously by Brown and Ferrara (1985) saying that "the student is led to levels of success previously not envisaged by neither the student or the teacher" (p. 302). This is true because "upper boundaries are seen not as immutable but as constantly changing with the learner's increasing independent competence at each successive level" (Brown et al, 1993 p. 35).

In both case studies formative assessment spurred a continual assessment of the teacher's own methodologies as part of a feedback loop. As teachers looked at learners' work in more detail, they saw discrepancies. But closing a perceived gap was not done in one easy single step. One step resulted in several others. Nor was the band-width of mismatch constant; instead there was continuous change in the participants' knowledge. In effect, just as a one perceived mismatch was closed, others opened up. Thus the process of assessing within the zpd was ongoing, so that formative assessment activities occurred over many cycles. In these two cases change developed over the course of a full academic year. Throughout each turn of the formative assessment cycle, discrepancies highlighted the need to move towards an ever-greater consistency between expected and actual (individual and mutual) goals. At each point, the teacher needed to change expectations or change teaching practice. This striving for consistency informed teachers' practice ongoingly. In both cases, by using formative assessment, the experts themselves were changed in their own thinking.

Scaffolding Tools in the ZPD

The primary scaffolding tools used during the formative assessment cycle were Harlen's questioning rubric in the California case, and the Inquiry Science

Endorsement in Pennsylvania. In both cases, the experts, over time, began to rely less on the standard rubrics and more on revised, self-selected strategies, as they became more able to select the strategies that helped the learner move towards more independent understanding. In both cases, an ever-increasing fine-tuning of scaffolding tool use, within iterative formative assessment cycles, occurred as teachers entered into collaborative relationships with learners, who were invited to co-construct ways of participating.

The teacher experts at the Exploratorium discussed questioning techniques with students, categorized questions, reviewed and revised them, iteratively, over the school year. They appropriated students' questions, and these questions became an object of research in and of themselves. By categorizing student questions according to the Harlen rubric, teachers relied on a beginning scaffold for organization, and for a method of guiding learners to meet their joint goals. They collected student questions in a variety of ways, but in all cases they noted distinct changes in student work, both qualitatively and quantitatively, and this resulted in an improved ability to ask questions by the teacher and the students over time.

In working together to determine the match between goals, both student and teacher jointly appropriated questions. The students gained insight into how to maintain their own questions with certain goals in mind. The teachers learned how to listen carefully to student goals and to find the questions that best suited these goals. As teachers learned that not every question needed to be answered and that questions served as a means to an end, both gained authority over the process. Teachers first gained these insights as they used Harlen's questioning rubric, but they quickly moved beyond that as they independently put into practice altered selection processes and modeled more sophisticated ways of guiding students' questions.

By systematically collecting questions and tracking how they changed over time, the teachers gained insights into the value of questioning, and their role in guiding their activity. As teachers moved beyond Harlen's guidelines, they determined that questions need to be constrained, and that students needed expert modeling in framing and carrying questions forward. They learned to trust their insights regarding management of questions in important ways. For example, we saw that Wendy transformed as she attended to her students' questions in ever more sophisticated ways and as she decided on next steps to help them in the zpd. Prior to this training Wendy and other teachers thought that each student question needed to be answered; now they have perhaps shifted to an understanding that, while each might be honored, only some will be answered. Before studying student questions directly, these insights did not occur. In her own words, Wendy said:

> *Over the past year, I have come to see that if I limit or constrain the questions to a manageable number—like five or six—my students still maintain ownership over what they want to investigate, and we also move towards the content I want to cover …*

[and later]

I did not always realize the power of questioning…

[and later]

By inviting students into the process of recognizing questions that can be investigated, I found that I help them to be better questioners.

In these statements, Wendy suggests that she has changed her ability to assess and guide children's thinking forward. Her statements indicate that she understands that she has improved her teaching practices in several key areas. First, she used student questions to inform herself of their understanding of content material; second, she allowed herself to constrain students questions according to some standard criteria, in this case California State Science standards; and third, she maintained collaborative ownership of the content and process by working towards mandated standardized goals collaboratively with students.

A comparable pathway to transformation was demonstrated in Pennsylvania by both expert and novice teachers through the use of formative assessment and mutual appropriation of products and thinking. Mentor teachers appropriated ideas about the skills used in teaching through inquiry from the teacher candidates, as well as from each other during the learning group meetings, continually revising the skill definitions and deepening their understanding of the implementation of inquiry. Therefore, while the mentor teachers promoted growth in the teacher candidates, they simultaneously examined their own practice in light of the use of a scaffolding tool, the Inquiry Science Endorsement. Progression in the skills and competencies of the teacher candidate occurred throughout the process in the course of the semester as did the transformation of mentor teachers' skills in the teaching of inquiry.

Barb, the mentor teacher, gained professional knowledge and personal skills by using the ISE guide but she was also able to move beyond it and to significantly contribute her insight to "assessing the usefulness of the ISE as a way to accurately assess novice teacher's performance." This mentor teacher was formatively assessing both the novice teacher's performance as well as the usefulness of the guide itself. This is similar to the Exploratorium teachers' initial use of the questioning rubric, which they then moved beyond. This is another case of a teacher moving beyond external guidelines towards internalized versions as metrics.

Additionally, mentor teachers expanded their beliefs and skills regarding supervision of novice teachers. Rather than entering a traditional hierarchical relationship, where the mentor teacher is the sole "authority" about teaching and learning and simply watches for evidence of the accomplishment of certain skills typically required of teachers, these mentor teachers actively engaged in discussions with their respective teacher candidates, coming to a mutual understanding of the requirements of skill and competence. Thus, through joint productive activity and mutual appropriation of ideas about teaching and learning through inquiry, the relationship became a mutual learning experience propelling each forward in her own understanding.

In this case, in which the focus was on the teaching relationship between the mentor teacher and the teacher candidate, there was a deepening of understanding of inquiry for both the mentor teacher and the teacher candidate. For the mentor teacher there was also the increased ability to understand how to measure a learner's ability to understand inquiry. As stated earlier, "doing formative assessment allows the [mentor] teacher to reflect critically on their own understanding of inquiry, as well as to reflect on their own practice, as part of a unit of mutual growth. This feedback loop of mentor teacher and teacher candidate change propels each forward " with mutual appropriation of knowledge serving to improve the practice of both the expert and the learner simultaneously.

Implications

This paper presents a theoretical proposal explaining why formative assessment serves as effective and transformative professional development for teachers. While this is not meant as a "how to" for designing professional development, the research presented as case studies within this paper generates implications for the professional development of teachers. Together with the work of Tharp & Gallimore (1989)), Achinstein and Villar (2002), Jones, Rua & Carter, (1998) and others, we can claim to have the beginnings of a response to Ball & Cohen (1999) who asked for a "carefully constructed and empirically validated theories of teacher learning …" (p. 4).

Taken together, these cases studies of actual professional development move beyond the current interpretation of professional development in the sciences and mathematics (Loucks-Horsley, Hewson, Love & Stiles, 1998). Loucks-Horsley et al acknowledged that collaboration and reflection are essential to professional growth and cannot be minimized. This research, using Vygotskian theory as underpinning, explicates the conditions that encourage reflective activity to occur, by arguing that collaboration and reflection occur as a outgrowth of participation and appropriation in joint productive activity the zpd.

We are aware that other important discussions need to occur. One such discussion centers on the role of the scaffolding tool itself. Whether working directly with children or with other teachers, teachers started by using a pre-established set of guidelines or standards, i.e. scaffolding tools. In each of these cases, the learners were also aware of the expectations set forth in the tool and jointly negotiated the meaning of the standards with the teacher. In both cases, the tools established expectations, allowed the expert to determine the gap between expected and actual performance of the learner, and provided a lens for self-reflection. Using the scaffolding tool in these ways offered the expert support in making pedagogical decisions. While this research did not expressly explore the role and use of tools in joint productive activity, we are pursuing this issue in subsequent research.

There is another compelling form of scaffolding for experts in these cases. In each case, teacher research occurred collaboratively in the context of a teacher learning group, in which other teachers and researchers worked together to refine their inquiry into pedagogy. As members of these research groups, teachers were

actively involved as learners as they explored various aspects of inquiry, including questioning, rubrics, and other thinking tools, all the while having the support of other teachers as peers with whom to collaborate. Thus, as Rogoff described, teachers' "transforming roles" impacted their learning. In the role of teacher experts, learning occurred during the use of the formative assessment cycle with learners. In the role of learners, learning occurred for the teachers as they collaborated with peers to inform their teaching. This assumption of the dual roles of teachers as means of professional growth is also being further researched (Ash, Levitt, Cheong, Hess, Sciulli. 2001).

Conclusion

Using the notion of joint productive activity as truly mutual, we can ask as did Yeats, "How can we know the dancer from the dance?" Embedded in this question is the notion that each participant's activities, thinking and goals are intertwined even when one is teaching and one is learning. Using Yeats as a jumping off point, Wells has said that "in the teaching and learning process...the entraining movements of the other participants (the teacher in this case and the music) are just one part [of the overall activity], [as] the novice gradually constructs the organizing cognitive structures for him or herself and brings his or her actions into conformity with the culture-given pattern" (Wells 1999 p. 323). Yeats captures the essence of the conundrum of when is the teacher the learner and when is the teacher the expert. Wells suggests that entraining within the zpd is composed of the actions of all (teacher, learner, tools and/or other) participants and that within the zpd "activity can be seen from the perspective of the individual participant acting with mediational means or from that of the social practices in which they [are] and the mediational means are involved. The value of the zpd is that it allows us to look at both sides of this perspective simultaneously" (Wells, 1999, p. 322).

We have suggested that formative assessment, or assessment that informs learning, (Harlen, 1999; Harlen, et al, 2000), involves mutual appropriation as joint productive activity within zones of proximal development (Tharp & Gallimore, 1989). In this research, expert teachers appropriated learner cognitive products (sample work, questions, strategies, etc.) in order to decide among multiple competing strategies to help move the learner forward. We have argued that by using formative assessment, teachers are 'working within the zone of proximal development'.

We have provided evidence in the form of two cases studies that formative assessment provides a vehicle for growth for not only the learner, but for the teacher. In each of the projects, teachers' use of formative assessment propelled their professional transformation in tandem with the development of the learners as they self-monitored their practices through the lens of assessing the understanding of the learner. A developmental trajectory was proposed, in each case, out of the data from the two science education reform efforts. Such trajectories are based on the assumption that teachers grow professionally when they have an opportunity to study and modify their practices in the interest of student learning. The joint

productive activity involves all participants receiving and giving assistance mutually in the zone of proximal development.

Applying a new theoretical perspective to an existing set of educational challenges has far-reaching ramifications for educational practice. By using the zone of proximal development as the theoretical underpinning for formative assessment and professional growth, these cases studies have allowed a closer examination of the steps that involve both student and teacher change. The larger significance of this work lies in understanding why formative assessment works as an effective strategy for ongoing professional development across a wide range of teaching practice, from pre-service through experienced teachers, to university professors. This interpretation of formative assessment relies on promoting both reflective practice and mutuality of perspective founded on Vygotskian theory.

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Appendix
Sample page from the Inquiry Science Endorsement

SKILL # 2: DESIGNING AN INQUIRY LESSON

National Science Education Standards

Teaching Standard A: *Teachers of science plan an inquiry based science program. In doing this, teachers*
·   *Select science content and design and adapt curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.*
·   *Select teaching and assessment strategies that support the development of student understanding and nurture a community of learners.*
Teaching Standard B: *Teachers o science guide and facilitate learning. In doing this, teachers*
·   *Focus and support inquiries while interacting with students.*
Teaching Standard D: *Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers*
·   *Make the available science tools, materials, media, and technological resources available to students.*

CRITERIA
1.   Identify content and learning objectives clearly.
     Evidence: Statement of objectives of lesson.

                    Methods Professor or Cooperating Teacher   Date

2.   Incorporate a learning cycle in planning.

     Evidence: A science lesson plan with the components of a learning cycle (e.g. FERA, EEEEE, FOSS) framework.

                    Methods Professor or Cooperating Teacher   Date

3.   Make lesson plans that identify students' prior knowledge and understanding and establish motivation for and objectives for the activity.

     Evidence: Written lesson plans have students share their current understanding of the subject, identify learning interests, and clarify the goals of the activity.

                    Methods Professor or Cooperating Teacher   Date