Investigating Qualities of Teachers' Feedback Conversations for Fostering Reasoning and Feeling of Self-Worth in Learners: A tool called Feedback Mapping

Jennifer Ann Quynn

A dissertation
submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington

2013

Reading Committee:

Min Li, Chair

John Bransford

John Frederiksen

Program Authorized to Offer Degree:

College of Education

Investigating Qualities of Teachers' Feedback Conversations for Fostering Reasoning and Feeling of Self-Worth in Learners: A tool called Feedback Mapping

Jennifer A. Quynn

Chair of Supervisory Committee:

Professor Min Li

College of Education

Abstract

Teacher feedback has been identified throughout the educational literature as a powerful classroom intervention. However few tools exist that allow teachers to understand their own feedback practice. This study details a method for evaluating the feedback experiences of students. The feedback conversations of middle school science teachers were coded for length, initiation, reasoning, roles and critical position, and relationships between these qualities and student sense of self-worth were examined. Finding showed that feedback conversations tended to be short, rarely contained evidence of constructivist learning or reasoning, and teachers rarely expressed a critical position. It was also found that feedback experiences of students were tied to student self-worth indicated by overall score in the class. From what is learned, a process called Feedback Mapping is developed to visually capture this information and future recommendations for use of this process as a formative teaching tool for practitioners are made.

Acknowledgments

To the many advisers, wise counselors, and dedicated professors at the University of Washington whose lives' work has moved me and inspired my own. To my adviser and chair, Dr. Min Li, I am grateful for the energy and rigor you bring to all that you do and for believing in me from the start. I cannot thank you enough for adopting me as your graduate student, for introducing me to so much good educational research and providing me new opportunities for advancing my own inquiry. To Dr. John Frederiksen, who lives and breathes inquiry, and shares the reflective process out loud and with ease. I am that much wiser because of our many conversations over the years. To Dr. John Bransford, I thank you for inviting me to participate in your conversation on learning and for creating a climate that allowed me to dream about next steps and undiscovered possibilities. And to Dr. Denise Wilson who uniquely lent herself to my support in emotional and spiritual ways so that I would not be lonely on the journey. To you all, your professionalism and kindness will not be forgotten.

To dear colleagues and friends who, throughout this project, were patient with me and allowed me lots of chances to share my goals and explain my thinking. These folks reminded me regularly of why I do what I do and what truly matters in the lives of school children. To Tammy Tasker, who never failed to create a welcoming space for me to explore ideas and figure out what it means to learn. You have that rare gift of giving feedback that cuts to the chase, but doesn't cut. Thank you for always being there with your spirit that is ready and willing and able. And to Becky Vanderschaaf who supported this study in the very early

stages and in concrete ways, spending time learning to code conversations in the most professional and reliable manner. I will never forget the time you gave to this project and your sincere interest in its meaning. To Pamala Travedi who shared her own dissertation process with me, allowing me to visualize a pathway for my own, encouraging me all along to be where I am now. We both well know that all good things come to those who wait. For Corey Bartle who has never been too far away, responding to my confusion about logistical issues and always imparting words of wisdom that *keep it real*. And to so many other graduate school peers who contributed to my thinking over the years including Shinping Tsai, Elizabeth Sanders, Kieran O'Mahony, Jodi Newman, Cassady Glass-Hastings, Cheryl Gordon, Andrew Morozov and Phonraphee Thummaphan. This is a journey that I definitely did not make alone.

To my sisters, Janie and Juliet, who care for each other and so many others, from the heart, and still find enthusiasm for what I do and feel proud. Every person should have an advocate like you, and I am so fortunate to have two. And to my parents who value education, live life creatively and fully, and who taught me to be generous and to love. I realize how fortunate I am to have you as parents and how much your choices in life have framed my own.

In addition, I would like to acknowledge my children. To my daughter, Frances, I am so grateful for your caring nature, your pride in my work and for taking life on as the adventure it can be. You were never far away during this process with a smile, a story or a hug and I am so fortunate to have your support during my studies. And for my daughter Lilly,

who, during this time, taught me that it is possible to be very strong and very kind, simultaneously. Thank you for reminding me that you cannot fake passion and for teaching me to be my own best friend. Your experiences definitely informed this work. And to my daughter, Sophie, who understands the value of an opinion, who takes on big challenges and difficult questions, who keeps life interesting and who insists that I reason my way out of things. When I had to work you made the best of it, and spent your time adding to your own library of understandings. You are a wonderful role model for us all. To my daughters who have always been distinctly unique individuals and who make this world a much better place for me and for others. I cannot thank you enough for the sacrifices you made during my studies and for supporting my dream. You loved me, made me laugh, grounded and inspired me with your own inquiries. I look forward to supporting your dreams, so dream big.

To my husband, Allen, who has been a consistent fan over the years and who seamlessly adopts new roles and responsibilities so that our children can believe that nothing matters more than they do and they will always be connected to us. Your sacrifices were great and have not gone unappreciated or unnoticed. As with all times in our married lives, I expect to look back on this period nostalgically, remembering that I could not have done it without your devotion to me and to our family.

And, finally, to the National Science Foundation whose financial support allowed me to test my theories of learning and feedback in classrooms outside of the U.S. Thank you for the unique opportunity to explore feedback through a cultural lens and understand it as fundamental to learning for us all.

This dissertation is dedicated to

Itshupeng, my student at Madiba Senor Secondary School in Botswana

and to the school children and educators who died in the shooting last week at Sandy Hook Elementary in Newtown, Connecticut.

Table of Contents

Chapter 1: Rationale

Introduction

This project started in 1989 in a village named Mahalapye in the southern African country of Botswana. I didn't realize that my experiences then would inform this dissertation work all these years later. I had joined the Peace Corps at 22 years old and was eager to try out the teacher training I had received at my state university. Madiba, one-story, cinderblock and tin roof government high school was divided down the middle by a wide, sandy courtyard. To allow for any possibility of air circulation, the windows and doors of the boarding school were propped open, and any passerby on a hot Botswana weekday could observe the level of classroom activity within. During afternoon lessons, some teachers battled to draw their students back from heated delirium, back to the lesson and into the learning. In other classrooms, the teachers had surrendered to the heat themselves and so the heads of African teenagers rested on gray worn, metal desks. The activity level of each classroom related directly to the effort of the teacher to engage students in conversation and to draw them into the learning.

It was during this Peace Corps experience that I first discovered the power I had as a teacher to engage my students through conversation and in reasoned thinking. Conversations I had with a student directly impacted the amount of effort they put into classwork, the skills they attained and attitudes they adopted about being in my class and the value of spending time learning math. Qualities of the conversations I had with a student had a bearing on how

successful they felt they could be learning math, the level of quality they believed they could achieve, and what they thought they would come to accomplish in the future.

I write this dissertation relying on my teaching experience in Botswana and on additional classroom experiences since then. However, that first job as a teacher in Africa began the formation of certain fundamental beliefs that I continue to draw upon and that are assumptions that must be considered by any reader of this dissertation study. They are:

- Teachers exercise incredible power in classrooms by the way in which they choose, and chose not, to interact with their students. How this power is distributed by teachers is critical to understanding how students become engaged in learning and what they come to know and understand.
- To justify any assessment, the activity must inform instructional practice and lead to improvement in teaching and in learning. Research, as a type of assessment, must adhere to this principle; it must be based upon reliable data that have meaning to classroom teachers in support of practical improvements in their professional practice. There is no other way to justify research.
- The teacher is the main stimuli producer in the classroom - the one who has developed a practice of stimulation. It is the individual interactions or conversations between teacher and student that define this practice of stimulation or feedback that is embedded in classroom instruction.

This dissertation reflects my long held desire to identify and understand teacher feedback practice by looking at patterns of feedback conversations that take place between a

teacher and his/her students. These *feedback conversations* or *feedback events* when documented expose patterns of teacher behavior and illuminate the experiences of students by way of their involvement and information shared.

Students are rarely exposed to the authentic work and reasoned thinking of field scientists, engineers and mathematicians in K-12 science, technology, engineering, and mathematics (STEM) education. Because of this, they rarely adopt the goals and thinking habits of engineers and scientists. U.S. secondary math and science educators hold limited understandings of what it is that scientists and engineers do (Black & Wiliam, 1998) and are under increasing pressure to narrow learning objectives and thinking in this ubiquitous race to improve standardized test scores. Currently, the educational focus in U.S. public schools remains on "heavily cued questions on very small fragments of information" (Bangert-Drowns et al., 1993, p. 233). And increasingly greater pressure is placed on teachers to deliver lessons that are identical to their colleagues, making the job of *teacher* one of conforming, more restrictive and less creative. However, during classroom interaction teachers are unrestrained and remain free in their responses to student thinking. They are free to react and to do creative work, on-the-fly during feedback conversations with their students. In this way, teachers can engage students in the similar activities of scientists and engineers, the practice of reasoned thinking. Within these feedback conversations, teaching is preserved as a selective, professional, intellectual endeavor where teachers build a unique practice of feedback, creating independent and responsive experiences for students.

It is within the pages of this dissertation that I explain the way I understand teaching and its impact on learners. I do this based upon my own experiences as a teacher and what has been identified previously within the educational literature on feedback. From this foundation, I seek to explain the power of feedback by developing a method of coding and capturing patterns of feedback conversations between teacher and student and understanding the qualities of these conversations. The process allows for understanding feedback in terms of student involvement as a necessary component of building a sense of learner self-worth and understanding of future contributions as a science learner. Understanding feedback in terms of student involvement explains who gets invited in conversations with the teacher and who feels empowered to seek feedback or initiate a conversation, something that successful learners have been shown to do throughout much of the educational literature. This study seeks to understand the relationship between students' experiences with feedback conversations during classroom learning and the value students feel as contributors in the process of studying science.

Developing a feasible method for understanding relationships between qualities of teacher-student conversations and sense of self-worth in learners holds great potential in the quest to improve learning of K-12 STEM content and any other learning that is considered socially constructed knowledge. The dissertation study focuses mainly on the qualities of feedback conversations and how they are distributed in teacher feedback interactions. The end goal is to demonstrate a technique that presents information that can be used formatively for teachers to better their craft. For teachers to be more effective, they will require reliable and

convincing information about their own personal practice to improve upon a current way of knowing and doing things. The methodology shared in this dissertation is applicable to bettering the feedback practice of any teacher in any classroom setting as long as teacher and students are using feedback conversations to advance learning.

What teachers do within teacher-student conversations and within the feedback practice they build has immediate value for students and holds potential value for learning futures. Teacher conversations with students provide students information that they use to understand themselves as learners, as people, as participators in a classroom and as future scholars. These conversations can be tracked as patterns of feedback conversations and they are powerful experiences for students, yet they happen informally, on-the-fly, and in real time, with little opportunity to reflect in busy, crowded classrooms. The aggregate of feedback conversations of individual learners with their teacher makes up the feedback practice of a teacher. These teacher-student encounters are profound and fundamental because they also inform how students envision themselves in the future and the contributions they might make as scientists and engineers.

Teacher feedback is a tool used to leverage or draw students into learning as a process. It is this engagement that leads to learning and improved student understanding. Leveraging student thinking happens at the individual student level, and impacts students uniquely and independently. This leveraging of student understanding pushes beyond content knowledge to include how a student sees himself/herself in classroom environment or their sense of self-worth and potential to engage further in the learning pursuit. What a student comes to know

about their own value as a learner, their role, their prospects, and even their interest in learning beyond the lesson are lasting and deep understandings, greater than conceptual knowledge. In much of the earlier research on teacher feedback, content and lesson objectives defined the purpose for studying teacher feedback. In this study, it is all about understanding student experience, engagement and value as these relate to the feedback conversations they have with their teacher. In this study, I argue that student score in the class, the average of many formal assessments, is not necessarily a valid indication of achievement, but it is seen as a measure of how a student feels about themselves as a learner in the class (Thomas & Oldfather, 1997). The intention of this study is to understand how academic score or indicator of student's sense of self-worth relates to the quantity and type of feedback they engage in with their teacher.

Teacher feedback can be intentional, such as when a teacher asks a student for their rationale behind their thinking. However I am also interested in understanding the tacit feedback which may be unintentional feedback which is information that students get from teachers in the absence of communication. There is information in neglect. When a student attends a science class for an entire week and has absolutely no interaction with the teacher, information is communicated about the level of contribution the student can make to the learning. This informs the level of value a student experiences in the class. What is learned through neglect is the most damaging information. A student who looks from the outside in at feedback conversations taking place between peers and teacher cannot develop a healthy and positive understanding of what they have to contribute today and in the future. A teacher's

feedback practice is made of quantity of feedback conversations for each student and the qualities of conversations experienced by each student. What matters is the unique way that students experience, or do not experience, feedback conversations with their teacher. A teacher's feedback practice must reflect opportunities that were not realized for individual learners. This work does not look into specific instances of certain types of teacher feedback conversations. It is about general practices of teachers and how they distribute their feedback craft to students considering how students feel about their value within the learning process. There are students who engage very little, or not at all, with their teacher. This becomes the unique experience they have with feedback conversations and it is very important in understanding teacher feedback as a practice.

Feedback is much greater and more powerful than traditionally described by the educational literature. It is intentionally and unintentionally used by teachers at all times during a classroom lesson. When teachers withhold feedback, the message students get is that they have nothing of value to contribute to the learning process and feelings of student worthlessness are reinforced when there is no engagement with teacher. When teachers engage in feedback conversations with all students, they provide a universal, open invitation for students to improve their own value or sense of self-worth by contributing to feedback conversations. When students look for evidence of their value within feedback conversations and experience reinforcement of what they already knew from their score in the class, the opportunity is lost to exercise the power of teacher feedback to change the way in which a student sees their contribution to learning science now and in the future.

Students with high scores in science enjoy a high level of self-worth as science academics and students with low scores feel they have less to contribute and are less connected to the learning process. These feelings that are commensurate with student score identify the desire a student has to continue studying science. Within this dissertation study I ask, “Does student sense of self-worth relate to the feedback conversations they have with their teacher?” and “Could it be that teachers reserve a certain amount of feedback energy and certain types of conversations for certain students?” If student score represents the contribution students are asked by their teacher to make during feedback conversations and represents productivity, success and potential, then teacher feedback is not utilized by teachers as the powerful intervention it has been identified as in the educational literature (Hattie & Timplerley, 2007). If students cannot be distinguished by the feedback experiences they have with their teacher then what is demonstrated is a teacher’s practice of equity and equalization across students and within a lesson. To understand student experience as individual within a teacher’s feedback practice has enormous implications for shaping better practices for teachers.

Educational reform requires good theory, but it must be supported by data that are believable to teachers in the field for this is what draws a professional to understand their own practice, to reflect, to identify deficiencies and inequities and press for new, higher standards of practice. It isn’t theory that does this. This is done using classroom data. To create a research study that has the potential to influence teacher practice requires a methodology that practicing teachers can envision. It must be parsimonious, involving only what is necessary to

identify those patterns of feedback conversations of teachers with students. The research process must by replicable for classroom teachers who want to understand and affect the feedback experiences of their students. Today, more than in the past, the process must be efficient, feasible and replicable and produce information teachers require to be interested in and to scrutinize their own practice. For this is what leads to informed and progressive change.

And still, there exist excellent reasons to avoid measuring teaching behavior or teacher feedback altogether. If measuring teaching results in fear and hostility among teachers and students, it should not be done. If measuring teaching fosters an environment in which teachers want to close their windows and draw the shades and become less involved in developing their own theories of teaching and learning, do less for their students or employ less creativity in learning solutions, then measuring teaching does more harm than good and should be avoided entirely. Assessing a teacher's practice provides benefit only if it produces new information that is used in formative ways for teachers as they become more effective professionals. Creating and using a measurement tool, researching or assessing teachers can be justified only if the effects are positive, leading to increased student engagement and greater satisfaction for teachers in classrooms.

In this descriptive study, generalizability is cautioned and readers are strongly encouraged to entertain alternative explanations based upon their own theories and experiences. Findings must be limited to only those teachers who participated in this study. A literature review explores the ways that learning and feedback have been conceptualized in

the past and this tends to represent a more narrow focus on the conceptual understandings of students. Teachers certainly do craft feedback and press student understanding for purposes that are measured by traditional, formal assessments such as standardized tests. However, the focus of this study is on student engagement and not learning that is suspiciously and too often claimed to be detected by large scale tests. Students develop many understandings over time and these include how they understand their value as a learner. Teachers, as the main stimulus producers in their classroom, are instrumental in developing these understandings and this happens within their own feedback practice. Teachers keep student heads up and off desks and press for greater engagement, a goal detected by measures of the qualities of feedback practice.

Within this dissertation, my curiosity extends to how student experience with teacher feedback relates to student achievement and I use student score, or overall class grade, as a proxy for how students feel about themselves as successful learners in the class. I hypothesize that students who experience a certain level of self-worth also experience certain qualities of teacher feedback. This relationship has bearing upon how a student engages in science learning in the future and so on future sense of self-worth. Put another way, the feedback events that students experience are related or correlated with their achievement level in the classroom. In this study I seek to explore the strength of this relationship and to understand if high scoring students are more likely to initiate interactions. If so, it may be that students who enjoy a high sense of self- worth have what is required to initiate feedback conversations with their teacher.

To achieve, a student must believe that he or she has *learner value*. And this is the greatest teaching dilemma – communicating learner value to multiple students. It is vital that teachers understand their feedback conversations as powerful opportunities in real-time to leverage student self-worth during instruction. Within this dissertation, I seek to explore these powerful leveraging feedback conversations to understand how they are distributed among a group of learners and consider how qualities of these conversations impact the sense of self-worth that students experience. Understanding the extent to which feedback conversations not only impact student engagement today, but influence future engagement builds greater urgency for work that has not yet been done in research on teacher feedback. Teachers impact how a student feels as a contributor in the lesson and so learner equity must be considered a factor when measuring a teacher's practice. Teachers who realize that feedback conversations impact student self-worth will build a far busier, more effective practice made of meaningful conversations that are equally equitable to all students. Within such a practice, certain characteristics of feedback will not be evident or reserved for only learners at certain score levels. The quality of a teacher's assessment practice must include who experiences which types of conversations. Students should not receive feedback that simply perpetuates and illuminates the level of success they already experience in the class.

Ideas drawn from both Behaviorists and Cognitivists are represented in the conceptual foundation of this study. My understanding of learning is broader than that of most feedback researchers — I understand learning as student engagement. When a teacher asks a student a question, the student engages and responds. It is an automated reaction — unplanned,

unscripted, and on-the-fly — very similar to learning as understood by behaviorists in early feedback research. At the beginning of a conversation, a teacher stimulates a student by asking a question and the student responds. Student engagement begins. Teacher feedback is the necessary stimulation or the catalyst for student engagement in learning and engagement is the essence of all learning. After this initial stimulus-response initiation, cognitivists explain what happens within the feedback conversation in creating new understandings that are shared. During the engagement of feedback conversations, students reach new understandings and consider new information about themselves as learners. Within the feedback conversation, a student comes to understand that they have a contribution to make and that they have value. This outcome of feedback conversations happen because teachers are willing to play an alternative role and engage students in ways they have not experienced in the past.

Feedback conversations serve as that stimulus that individual students require to engage and when they happen they elicit new understandings. Without a teacher who is willing to serve as the main stimuli producer, students remain disengaged and undervalued by themselves as learners, even if their heads do not rest on desks.[1] And when teachers see themselves as the main stimuli producer for all students, their feedback practice is equitable and student engagement is not delayed.

[1] It is the case that students can stimulate each other to be engaged during lessons. However, this work recognizes teacher feedback as the uniquely powerful stimulus that moves students to better understandings of their worth as learners. And so, this study focuses solely on teacher stimulation or teacher feedback to the exclusion of other sources.

This dissertation is not a detailed look at specific instances of exactly what is said during a feedback conversation. It is birds-eye view of a collection of the many feedback conversations that happen during a series of lessons. A final representation of these events is shared in Chapter 5, *Discussion*. There is an example of how all feedback conversations during one lesson can be represented or mapped back to each student in the class. By identify and coding every feedback event during five consecutive lessons, patterns of feedback quality emerge. To understand these feedback events by student in terms of self-worth allows for understanding the type of relationships created and nurtured within the classroom, which is the footprint of a teacher's feedback practice.

This study is not strong on predicting the practices of teachers beyond those who were participants in the study. This is a descriptive exemplar of the feedback practice of four teachers who work closely together in the same department of one urban middle school and who deliver scripted lessons written by district administrators who work to streamline lesson message. Under this constraint, the assumption can be made that the feedback practices of teacher participants are more similar than those of other teachers who share less. I theorize that teacher feedback, even under strict curriculum and program limitations, remains the unique footprint or identifier of a teacher's practice and that this research method for identifying the qualities of teacher feedback can be used to understand and feedback practice. These indicators are extremely valuable information for understanding what students experience as it relates to their self-worth in the class.

The rationale for this dissertation has been written twice, this being the second, more informed version. After the initial attempt and just while the ink was drying, something significant occurred in the life of my school-age daughter. This situation informed my second attempt in a couple of ways. While the way in which this event was handled diminished the voice of my daughter, for me, as her mom, it had the opposite effect. I discovered my voice and found myself empowered to write with greater expertise on this topic. I learned from my daughter's experience the true importance of this dissertation as well as the urgency for delivering its message. I realized the true danger of failing in feedback conversations. I came to understand how desperately important it is that we get this right for students in schools.

As a teacher, I realized early on that my feedback impacted student behavior. I crafted my feedback, I thought, because it advanced the knowledge and skill that I had been told were important for my students. My experiences as the parent of children in school have forced me to revisit my earlier, limited view of teacher feedback. I have a new understanding of the value of teacher feedback and how it works for students. I see student score in a class as an indication of the value they have for themselves as a learner and as future contributing scholar. And feedback is the tool of leverage a teacher uses to improve learner sense of self-worth. Because of this, teachers must develop a feedback practice of efficiency and effect for all level of learner, and particularly for those who demonstrate low sense of self-worth.

This research that presents formative information about teacher feedback practice will lead to greater student engagement in STEM learning and in all areas. Many middle and high school students remain strangers to success when it comes to learning math and science and

they feel alienated in the process and under engaged, e.g., minority students, students of poverty and women. As well, teachers have not utilized the power of feedback (Assessment Reform Group, 1999; Black & Wiliam, 1998) which can improve student engagement and learning for students at all levels of achievement (Black & Wiliam, 1998; Brookhart, 2004; Hattie & Timperley, 2007; Mory, 2003; Torrance & Prior, 2001; Sadler, 1989; Shute, 2008).

My dissertation work is an added passionate voice to those who have already declared that teachers absolutely do matter in classrooms. This work builds on the evidence that teacher feedback plays a vital role in the learning process. Teacher feedback works not because it improves student achievement scores, but because it leverages a higher level of student appreciation of himself or herself as a learner. Teacher feedback engages students, presses them forward in their learning and sustains them in life.

Chapter 2: A Review of the Literatures

Overview

This chapter explores the ways in which feedback has been conceptualized and studied in past educational research, considers findings from other educational literatures, and suggests a new way of looking at the meaning and value of feedback. The intention of this chapter is to identify findings from research on feedback that support a framework that allows for understanding teacher feedback as a practice that is constructed over time in a classroom and something that teachers do day after day that matters in the lives and learning of their students. Identifying qualities of feedback that explain the practice of a teacher advances the goal of this dissertation which is to demonstrate a feasible, reliable method for capturing a teacher's feedback practice and understanding how it is distributed to students during classroom instruction. Research literature addressed herein contributes to the foundation for understanding how feedback works in conversations between teacher and student, the qualities of these conversations, general patterns of day-to-day classroom interactions between teacher and students and how these conversations can be mapped back to individual learners in order to understand the unique experiences students have with their teacher's feedback.

Within the educational literature there are few opportunities to look at feedback as a general practice that teachers build and apply. An overall look at teacher feedback illuminates the habits of teachers and the engagement experiences of individual students that ensue. There is value in research that offers a method for understanding how a student fits into their

teacher's feedback practice during the lesson and what they gain. Studying teacher feedback as an inclusive, holistic generic set of teacher habits provides information that is the formative spring board for discussion, reflection, and adjustment to a practice. The literature review shows that research of this nature, about teachers and for teachers, based upon actual classroom feedback conversations, is sorely needed. And so begins this literature review.

Assessment

The term *assessment* is used throughout educational research to describe "Any process that provides information about the thinking, achievement or progress of students" (Crooks, 2001). Assessment has been written about extensively and identified distinctly as summative and formative assessments, that can be distinguished by purpose (Black & Wiliam, 1998; Sadler, 1983), effect (Black & Wiliam, 1998; Sadler, 1983), and timing (Hattie & Timperley, 2007; Mory, 2004; Shute, 2008).

Summative vs. formative. Summative assessment exists outside of instruction and provides a report of student learning or achievement, while formative assessment or classroom assessment is embedded or inlayed into "day-to-day teaching" (Harlen & James, p. 370) and includes "… all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged" (Black & Wiliam, 1998, p. 8). While summative assessment is used to summarize student learning at a given point in time, formative assessment is used to produce or ensure future student learning (Crooks, 2001). Formative assessment, the common activity of an effective teaching practice (Bailey & Jakicic, 2012;

Bloom, 1969; Brookhart, 2009; Sadler, 1989; Scriven, 1967; Wiliam, 2011;), is in progress whenever teachers investigate student understandings and use what they learn to modify their teaching, improve learning for the class in general or for students as individual thinkers.

In order to effectively implement a practice of formative assessment, teachers listen to students because they know that "there is often information about *how* to teach something better in what students say – and thus how to adjust the instruction to better meet students' needs" (Black, 2011, p. 85). This kind of inquiry listening is at the heart of formative assessment interactions that happen between teacher and student, that are inclusive and allow for reasoning to be shared (Black & Wiliam, 1998; Bloom et al., 1971; Sadler, 1983;). Formative assessment shifts the role of teacher from listener as evaluator (Davis, 1997) to one who recognizes that their students must play different parts in the assessment process if they are to become self-actualized learners who adopt higher, more long-term learning goals beyond those limited in didactic instruction. The ultimate goal for teachers is to foster "…the ability of students to exercise executive control over their own productive activities, and eventually to become independent and fully self-monitoring" (Sadler, 1989, p.120).

Learning as an interactive process. There is increasing evidence in both theoretical and empirical research to suggest that individual learning in classrooms is not an isolated experience, but rather, the result of interpersonal interactions (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991; Marx & Walsh, 1988; Palincsar & Brown, 1984; Pintrich, 1993; Resnick, Levine, & Teasley, 1991; Tharp & Gallimore, 1988). Given that we know learners actively construct meaning (Bransford et al., 2000), teaching must be

understood as an interactive process. Smerdon, Burkam and Lee (1999) explain traditional teaching in this way:

> "Didactic (or direct) instruction traditionally has been conceptualized as the transmission of facts to students, who are seen as passive receptors. In classrooms where this type of teaching predominates, teachers typically conduct lessons using a lecture format. They often instruct the entire class as a unit, write notes on the chalkboard, and pass out worksheets for students to complete. In traditional classrooms, knowledge is presented as fact, students' prior experiences are not seen as important, and students typically are not free to experiment with different methods to solve problems. In traditional classrooms, it is the teachers who are active; they convey facts and inculcate knowledge. Students are passive receptors of this knowledge. These classrooms typically consist of teachers presenting the "right" way to solve problems (or even the "right solution")."
>
> (Smerdon, Burkam & Lee, 1999, pp. 8)

Waller (1932)[2] characterized traditional methods of instruction by the way that teachers assume authority and behave distantly toward students. For traditional methods, feedback would then appear to be a one directional force, from teacher to student. Yet

[2] as cited by Smerdon, Burkam and Lee (1999).

effective teacher feedback has been identified within student-teacher conversations or the interactions that take place between teacher and student (Chin, 2006; Bandura, 1977; Hattie & Timperley, 2007), an opportunity that is not afforded in traditional teacher-centered methods. I suggest that didactic instruction is most comfortable for many teachers because traditional teaching is more of a classroom management tool more than a teaching tool and teachers assume control in this model of learning and roles of teacher and student are clear. Traditional, didactic instruction is less complicated and keeping it simple is more easily accomplished in this way. In the didactic arena of learning and in traditional classroom settings, feedback takes on a quality of efficiency and looks like teacher stimulus and student response.

Teachers can find support from learning communities for traditional approaches and didactic learning. Many students experience a culture of home where learning is introduced by authority and knowledge is didactic and can be memorized – knowledge is recall. From young ages, students are taught this by care-givers — memorize birthdays, addresses, nursery rhymes, favorite brand symbols. And popular TV presents learning as memorization, such as in the game show Jeopardy. I hold that within this traditional didactic view of learning there exist benefits. There is a place for memorization in learning, e.g., procedural knowledge is efficiently taught using didactic methods (Li, 2001; Li, Ruiz-Primo, & Shavelson, 2006). It is not that teacher-centered methods are wrong it is only that learners have limited experiences when instruction relies solely on one method. Opportunities for student engagement are limited.

It is clear that opportunities for learning must be richer and that learning is supported by more than teacher-centered instruction. Opportunities must allow for what is discovered between people. The early 20th century Russian psychologist, Vygotsky (1978), based his theory of socioculturalism in part on the claim that learning occurs within the interaction between people and their ideas (Wertsch 1985). Human thinking is inherently social in its origins (e.g., Sfard & Kieran, 2001; Goos 2004). For this dissertation study, feedback that addresses learning beyond memorization, must be more involved and produce patterns of variety beyond teacher stimulus and student response.

Within this dissertation study, full emphasis is placed on feedback as a formative assessment process of interactions between teacher and students, designed to engage students for the long-term, affecting student understanding that happens in the moment and understanding that lasts into the future.

Introducing Feedback

For the many who have written extensively on what distinguishes summative assessment from formative (Black & Wiliam, 1998a, 1998b, 2009; Crooks, 1988 & 1991; Hattie & Timperley, 2007; Mory, 2004; Ramaprasad, 1983; Sadler, 1983, 1989, 1998; Shute, 2008) the key ingredient is *feedback.* In Mirriam-Webster's on-line dictionary, the term *feedback* is defined as "the transmission of evaluative or corrective information about an action, event, or process to the original or controlling source". However, this definition of "transmission" makes learning sound very traditional and didactic for there is a "controlling source". That would make the student the one being controlled. Sadler (1989) wrote that

"*Feedback* is a key element in formative assessment, and is usually defined in terms of information about how successfully something has been or is being done". In this case, the emphasis is on information and it isn't clear that one it is controlled by any one person. Most commonly in the educational literature, feedback is sited as "...information about the gap between the actual level and the reference level of a system parameter which is used to alter the gap in some way" (Ramaprasad, 1983, p. 4). This definition draws attention to the deficit that exists. Hattie and Timperley (2007) refer to feedback as "information provided by an agent (i.e. teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding" and there are infinite sources of feedback as long as "feedback is a 'consequence' of performance" (Hattie & Timperley, 2007, p. 81). And this definition opens up the field too all possible sources of feedback that happen because something was performed or done. From all of the previous definitions of feedback there is benefit. I now further explore the meaning of feedback, more carefully considering the type of *gap* feedback is designed to detect and address.

Feedback and the gap. For the purposes of this study, I return to the definition of feedback from Ramaprasad (1983) and the idea that a "gap" exists. I choose to build from this definition because the type of gap that I am interested in addressing within this dissertation work is not fully recognized in the feedback literatures. However, the gap of my interest must be closed before any other gaps can be addressed.

I am interested in the gap between how a student feels about their usefulness as a learner in the class and the potential they have to feel value as a science or math learner. In

any given classroom, there exists the possibility that all students will experience a high sense of self-worth or value as a learner, feeling strongly that they have something unique to contribute to the learning process. In many classrooms students feel alienated and out of step, unworthy of learning STEM content. When this is the case, and this is the case for too many K-12 learners (Thomas & Oldfather, 1997), there are many great gaps between potential and actual feelings of self-worth. Within this dissertation study, I press to expose and place emphasis on learner sense of self-worth as a deficit, and consider the possibilities that feedback has for impacting this crucial student factor. I place the pursuit of closing the gap between actual self-worth and potential self-worth of learners at the pinnacle of all the worthwhile things that teachers do and propose that it will be closed, as all gaps have the potential to be affected, by way of teacher feedback.

In previous research, feedback has been studied in a variety of ways. It has been studied according to who gives the feedback, teacher, self or peer (Black & Wiliam, 1998; Hattie & Timperley, 2007,) by timing, immediate vs. delayed (Kulik & Kulik, 1988; Stiggins & Conklin, 1992), and by type of judgment or critical position involved (Stiggins & Conklin, 1992; Tunstall & Gipps, 1996). Meta-analyses have concluded that feedback is a powerful intervention and impacts student achievement (Bangert-Drowns et al., 1991; Black, 2011; Hattie & Timperley, 2007; Kluger & DeNisi, 1996; Kulik & Kulik, 1988; Yeany & Miller, 1983). For example, Black and Wiliam (1988) identified feedback as effective for all learners, related to teacher and student interactions, most effective when it is timely, and allows the goals of teacher and student to be communicated and negotiated. Within this review of the

literatures, I categorize feedback factors in terms of timing (Kulik & Kulik, 1988; Black & Wiliam, 1988; Hattie & Timperley, 2007), information (Winne & Butler, 1994; Kluger & DeNisi, 1996; Mory, 2004; Shute, 2008; Wiliam, 2011), and effect (Winne & Butler, 1994; Wiliam, 2011; Chan & Lam, 2010) to discuss the research on effective feedback.

Feedback and timing. In the earliest studies of feedback, experiments were conducted using feedback that was timely and designed as stimulus to elicit a response (Thorndike, 1922; Pressey 1926; Hull 1943; Skinner 1938 & 1954; Gange 1965). In early and simple experiments on stimulus-response, timeliness had to be a factor if other stimuli were to be controlled for and explanations limited. It was determined that learning, as defined at the time as memory or recall, is most impacted by feedback that is immediate over delayed feedback (Pressey, 1950; Skinner, 1954). It was during the Programmed Instruction Movement (Porter, 1957), that learning was identified narrowly as the act of recalling and research sought and questions were asked to understand feedback timing in relation to "human memory associations" (Clariana et al., 2000). Later research advanced the theory of learning and what it means to learn to arrive at greater complexity. [3] Later on, in a landmark meta-analysis, Kulik & Kulik (1988) synthesized the findings from 53 earlier studies in order to explain feedback and timing. They asked whether and under what circumstances it is best to provide immediate feedback versus delayed and looked at three types of empirical research. The chosen studies varied in terms of the degree to which feedback was delayed, how

[3] As the meaning of learning became more complex, so did the explanations of timing and feedback. And in the first learning experiments, subjects were not considered as individuals who have impact on study findings. There was no consideration of learner characteristics, needs or learning complexity.

learning was measured, and if identical or parallel questions were used in a follow up test. Results varied by each of the three study types – applied classroom quizzes, experiments on test content and experiments on learning a list. In the case of applied studies, immediate feedback was found to be superior to delayed, whereas delayed feedback is more effective for learning under experimental conditions of test recall. These results suggest that classroom teachers who want their students to learn under quiz-type conditions should provide feedback *as soon as possible*.

I adopt the findings of Kulik & Kulik (1988), and suggest that timing is a crucial part of teacher feedback if it is to be considered an interaction or the engagement. I also borrow from the earliest research on feedback and timing and suggest that teachers serve as the main stimulus producer in their classrooms. They are the ones who ensure student engagement. However, I recognize that within conversations, teachers must take on roles other than stimulator and that research done under test conditions lacks the ecological validity to explain feedback in the day-to-day practice of a teacher. While looking at a teacher's feedback practice, I value timing and immediate interaction as an indicator or involvement and engagement. It is through these interactions and the timeliness of the responses that teachers and students build relationships and demonstrate the value of the other.

Feedback makes assessment formative and to do so, it must be timely for there *is* an expiration date when information can no longer be of use, e.g., information elicited at the end of an instructional unit cannot be considered feedback unless it is used to inform further instruction and learning (Sadler, 1989). Feedback must be a rapid response if it is to be valid.

During student-teacher interactions, timely decisions are made based upon in-the-moment information. This rapid exchange between teacher and student leads to an increase in student motivation and achievement (Black & Wiliam, 1998). However, as rapidly as feedback can be crafted, learners *need time to thoughtfully process information* if the focus goes beyond rote memorization and includes reasoning or the opportunity to devise next steps in the learning process (Torrance & Pryor, 2001). Therefore, I am interested in looking at timing in terms of frequency within the lesson and length or number of moves that teacher and student engage as a measure of student experience within teacher feedback.

Feedback must happen sufficiently and frequently, be motivational and encourage thoughtful reception of information (Brookhart, 2004). However, that is a tall order for classroom teachers working with many students at a time. There are challenges for teachers in reaching and communicating with students, particularly those who are not successful at methods of self-assessment and self-regulation, (Pintrich & DeGroot, 1990). Even so, teachers can communicate on an individual basis with students in feedback conversations regarding what is of value and gage how expert a student is on a given topic so that knowledge can be differentiated (Schwartz & Bransford, 1998).

Research conducted on feedback timing suggest that immediate feedback is superior to delayed (Kulik & Kulik, 1988; Kulhavy and Yekovich 1976; Crooks 1988; Black and Wiliam 1998; Brookhart 2004) and that effective teacher feedback practices look like active engagement embedded into conversations in any lesson. The term *assessment conversation* has been used in the past to describe an instructional dialogue and assessment embedded into

an activity already occurring in the classroom (Duschl & Gitomer, 1997; Duschl, 2003; Furtak, 2006). For this dissertation study, I use the term *feedback conversation* to refer to an interaction between teacher and student that is unscripted, on-the-fly and formative or used to close the gap between actual and potential student self-worth or student understanding of their value as a learner.

When a feedback conversation happens between teacher and student it is an interactive experience, it engages the student, it requires more involvement than simply receiving information. A feedback conversation is a back and forth experience and to do this, learning must be more than rote memory. Learning must involve more than repeating what has already been said, pressing the student further in terms of their role in the process and thinking that becomes reasoning. Feedback is effective because it is an on-the-fly, informal classroom assessment (Crooks, 1988) in which teacher and student react to the thinking of the other and construct new meaning (Bransford, et al., 2000).

When feedback is reactive and comments are tailored to individual student thinking, learners begin to value their contribution as unique and their thoughts and the way they learn as individual (Butler, 1987), but in order for a teacher to react and identify student uniqueness, they must encourage students to describe their thinking, on-the-fly (Rodgers, 2006). In large classrooms, teachers circulate and respond via feedback conversations and craft a feedback practice of efficiency. So efficiency, like timing, belongs to the study of educational research literature; how teachers distribute the kinds of feedback they craft is one way to understand the efficiency and effectiveness of their practice.

Research has found that tailored written comments are more effective than grades (Butler, 1987) however there are no studies that compare the effects of oral to written feedback. I return to the concept of timeliness to explain this, and purpose. The task of grading papers and evaluating for many is complex and arduous, and results in delayed responses that are not as effective as oral feedback (Sadler, 1983). Information that fails to address the current state of things (Black & Wiliam, 1989), such as written feedback, is too removed to be considered a part of a feedback process and takes on a summative purpose. In summative assessment, students do not engage in feedback. By contrast, conversations are extremely timely to student thinking because they are formative, embedded directly into the classroom lesson. When teacher and student engage in a feedback conversation, comments are reactive to student thinking.

Feedback and information. Teacher feedback is information that moves a student forward in conceptual understanding (Bell & Cowie, 2000; Black & Wiliam, 1998a; Sadler, 1989) as well as information that improves student engagement and self-efficacy (Bandura, 1977), or understanding of self as a capable learner (Zimmerman, 1989; Pintrich, 1993). Feedback has been found to contain different types of information, classified as procedural, process, metacognitive or self (Hattie & Timperley, 2007). Feedback information has been classified as evaluative, either positive or negative, or descriptive and useful in promoting student competence (Tunstall & Gipps, 1996).

I identify feedback as information that directly impacts a student's sense of self-worth as a science or STEM learner. And for this dissertation, I rely heavily on this to identify the

information contained in a feedback conversation where students are exposed to an experience that they use as information to inform their own sense of self-worth as a learner. I suggest that teacher feedback has incredible impact on students because it contains the evidence they need to build their level of learner value. I conceptualize teacher feedback, its power and influence on student identity, in an effort to understand a teacher's feedback practice and the experiences of students within that practice.

Feedback that contains information on the self, or self-feedback,[4] such as when teacher praises a student, has been shown to have a negative effect on student attitude and achievement compared with feedback that contains information about how to learn (Kluger & DeNisi, 1996), for feedback that focuses on the self, such as "nice job" or "good girl", is not within the learner's locus of control and cannot be affected by the learner (Hattie & Timperley, 2007). Control has been identified earlier as a theme in didactic, teacher-centered learning that produces a limited understanding of the purpose for feedback.

Although feedback research has identified different types of information, I break feedback events up into a series of teacher and student moves (Chin, 2006), each move carrying information about student experience and the potential to do more than simply deliver rote information. A feedback move can contain be the result of constructed or new information, something unique that hasn't been said or done in the lesson or in the past. This

[4] Self-feedback as it has been called is not to be confused with self-assessment or self-regulation, activities that have been found related to motivation and that lead to greater achievement and learning independence.

type of information is of interest in this dissertation study and I call it reasoning within this dissertation study. With the emphasis on *newness,* this study seeks to understand how new is the information within feedback conversations and how is this new information or reasoning distributed across students in relation to student achievement in the class.

Feedback and learning type. According to the educational literature, there is no room for doubt that feedback is a powerful classroom intervention (Shute, 2008; Hattie & Timperley, 2007; Mory, 2004; Bangert-Drowns et al., 1991; Fuchs & Fuchs, 1986; Kulik & Kulik, 1988) and no shortage of empirical studies that explain how feedback works (Clariana & Koul, 2006; Chin, 2006; Hajcak, 2005; Dihoff, et al., 2004; Butler, 1987; Elawar & Corno, 1985; Cardelle &Corno, 1981; Gaynor, 1981; Pressey, 1926 & 1950). However, there have been obstacles to understanding feedback research studies in total.

For the past 100 years, different research studies have not agreed on what it means to learn resulting in findings that don't build on each other or that even appear to conflict (Shute, 2008; Hattie & Timperley, 2007; Mory, 2004; Black & Wiliam, 1989). The mismatch of study findings to learning conceptualizations prevents the communication of practical guidelines for teachers who want to improve their feedback practice. In what follows, I discuss the feedback research studies from behaviorists' perspectives.

Early feedback research and behaviorism. The earliest feedback researchers[5] (Thorndike, 1922; Pressey 1926; Hull 1943; Skinner 1938 & 1954, Gange, 1965) shared the common understanding of learning as stimulus-response associations or the accumulation of

[5] For a complete review see Kulhavy & Wagner, 1993.

small and discrete steps that the learner will repeat when reinforced.[6] It is important to note that in theories of learning as the result of reinforcement, the only communication to the student was that a desired behavior occurred. There was no discussion or explanation as to *why* the behavior was favorable (Frederiksen, personal communication, 2012).

B.F. Skinner explains:

> The whole process of becoming competent in any field must be divided into a very large number of very small steps, and reinforcement must be contingent upon the accomplishment of each step. This solution to the problem of creating a complex repertoire of behavior also solves the problem of maintaining the behavior in strength…By making each successive step as small as possible the frequency of reinforcement can be raised to a maximum, while the possibly aversive consequences of being wrong are reduced to a minimum.
>
> (Skinner, 1954, p. 94)

In early research, approximately 1880 to 1960, learning was considered the automation of simple behaviors and feedback was the stimulation that drew these simple behaviors out. As noted in the introduction, the focus of this study is on feedback that impacts student engagement and I am only secondarily interested in how feedback impacts the learning of subject matter concepts or procedures. However, I rely on the perspective of

[6] For further review, please see Kulik & Kulik, 1988.

original behaviorists and position teacher as the main stimuli maker in a classroom, the one who is drawing out and promoting student engagement. When a teacher asks a student a question, the student's first response is automated. The student is automatically drawn to respond, if only for a moment. However, after the student is engaged, teachers move beyond the stimulus model, crafting different moves and elicit different types of student thinking and understanding, and experiences that inform a student's sense of self-worth and belief in their own contribution.

The behaviorist movement explains how a feedback conversation begins, in an automatic sort-of-way, but it also limits the meaning of learning to that which is recalled or memorized. When learning is this limited, questions about feedback are narrowed and interest shifts to how information, load, complexity, and timing impact learning (Mory, 2003; Shute, 2008). The behaviorist approach does not consider characteristics of the learner or explain feedback that does more than engage students and is comprised of many reactive moves (Chin, 2006).

Learning perspectives of cognitivists. The behaviorist perspective of learning as automation that draws an immediate response (Thorndike, 1922; Pressey 1926; Hull 1943; Skinner 1938 & 1954; Gange, 1965) does not explain learning that is formed, influenced, unpredictable or aspects of learning that are nuanced, such as when teacher and student undertake different roles within feedback conversations. The process of learning is more than elicitation because "…most human behavior is learned observationally through modeling:

from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action" (Bandura, 1977, p. 22).

The birth of cognitive science marked a new understanding of what it means to learn and what is involved in being a learner. While behaviorists view "learners and their behaviors as products of incoming environmental stimuli" cognitivists recognize learners as "sources of plans, intentions, goals, ideas, memories, and emotions actively used to attend to, select, and instruct meaning from stimuli and knowledge from experience" (Wittrock, 1982, pp. 1-2). The cognitivist view is refreshing because it empowers teachers to attend to their feedback as they craft interactions that no longer only begin a conversation and draw out automated responses, but that influence student thinking and benefit learners in individual ways. Both groups of theorists — behaviorists and cognitivists – consider stimuli important, but cognitivists build from the understanding of learner agency when reacting to stimuli. Bandura (1977) wrote "there is little evidence that reinforcers function as automatic shapers of human conduct" (Bandura, 1977, p. 21) and justifies the cognitivist view in this way:

> It is fortunate that consequences do not automatically enhance every response they follow. If behavior were reinforced by every momentary effect it produced, people would be overburdened with so many competing response tendencies that they would become immobilized. Limiting learning to events that are sufficiently salient to gain recognition has adaptive value. For lower organisms possessing limited symbolizing capacities there are

> evolutionary advantages to being biologically structured so that response consequences produce lasting effects mechanically without requiring symbolic processing of ongoing experiences.
>
> Reinforcement provides an effective means of regulating behaviors that have already been learned, but it is a relatively inefficient way of creating them.
>
> (Bandura, 1977, p. 22)

In my view and the position of this dissertation, teacher feedback is the type of experience that is sufficient enough to gain the recognition that Bandura notes will stand out for the learner, beyond stimuli-response. For this very reason, teacher feedback enjoys added prestige among all other sources of feedback that might exist, such as a book, another student, the sky, etc. (Hattie & Timperley, 2007).

Applying the cognitivist perspective, feedback practice needs to support the construction of cognitive learning. Brooks and Brooks (1993) developed benchmarks of assessment to detect when students were constructing new understandings. They found that teachers must desire to know and value *student ideas* and *ways of understanding* and be focused on big ideas and not small, isolated bits of information. The tool must detect when reasoning happens as evidence that engagement is leading to new ideas, new information, new thinking. Reasoning within teacher-student engagement is evidence that teacher believes new ideas are welcome, acceptable, necessary and satisfying. It is a very good thing to detect

reasoning by either teacher or student during engagement because this indicates a willingness to invite and play in unscripted ways with ideas that have not been explored in the past.

Furthermore, teachers must be comfortable and open to engaging with students over misunderstandings. So, a tool that measure teacher feedback would detect this type of willingness within a teacher's feedback practice.

Tunstall and Gipps' research (1996) which found feedback to be either positive or negative, explicit to criteria, individualized or used for classroom management and found feedback most effective when it is descriptive and non-evaluative. And descriptive feedback was explored by Rogers (2006) as an opportunity when teachers allow students to non-evaluative experiences. However, for this dissertation work, critical position is used to understand what it is that a teacher does and whether the teacher communicates a critical position to students for any reason (such as, making a judgment about the correctness of a student's idea or suggesting next steps to improve current work).[7] Such feedback supports a descriptive climate where the teacher is paying attention to the learning process and the student's emerging understanding (Rodgers, 2006). When this happens teacher passes the control of learning to the child. A new relationship of power has developed. Student engagement increased during these periods of feedback and so did the activities of thinking, involvement, processing and reflecting.

[7] Descriptive feedback is difficult - feedback intended as positive and motivational, such as praise or stickers, raised emotional issues of fairness concerns for students (Tunstall & Gipps, 1996).

Hogan et al., (1999) identified essential components for learning as a science and they are generativity, elaboration, justifications, explanations, logical coherence and synthesis and suggested that together these six categories make up a judgment of *reasoning* complexity and not a judgment of the correctness of a student's idea. Teacher-student interactions were examined to reveal that to advance reasoning in feedback, teachers react ("ok, good thought"), request information, repeat and elaborate on students' ideas, and communicate task expectations about what scientists do. In addition, they recognized that students reacted differently to their teachers and were more likely to practice higher learning behaviors with their peers and when teachers played the role of conversation regulator, students were less likely to use higher reasoning skills such as idea generation, elaboration, justification and synthesis of ideas. From this, teachers need to regulate the role they choose to adopt during feedback conversations(Hogan et al., 1999; Goos, 2004).

One important function that has been studied in the literature review is "error detection" (Hattie & Timperley, 2007; Kluger & Denisi, 1996). Error detection is crucial in self-regulation and necessary whenever teacher and student engage in feedback conversations that involve constructed understandings and reasoning. Reasoning cannot be a simple, linear experience. There must be back and forth, agreement and disagreement, and critical positions expressed. So, in understanding teacher feedback as a way to close the gap in actual and potential learner self-worth, there must be room for teacher to take a critical position and yet preserve or even advance student sense of self-worth.

Teachers share different types of information with their students in timely and formative ways. For example, teachers communicate affective information to students during feedback conversations and this includes their own attitude which has been found to impact student motivation (Hattie & Timperley, 2007; Mory, 1994; Shute, 2008; Bandura, 1977). Affective information is not as reliably coded as procedural information (simple directions) or process information (steps to follow in a process) or even metacognitive information (how to think about the activity of learning) (Hogan & Nastas, 1999). There is a great need to understand more about how attitudinal information is received and used by students. However, there is one definite type of information regarding feedback that is sorely missing in the educational literature. That is the information that comes as neglect or the absence of conversations between student and teacher or a lack of personal engagement. A teacher who chooses not to act as stimulus maker and does not initiate a feedback conversation provides potent and timely information that will lead to a greater gap between actual and potential sense of worth for the learner. When a student attends class each day and never engages with the teacher in conversation, it is the absence of interaction experience that is the information the student uses to understand their own contribution now and in the future. I would suggest that this is how we lose many potential candidates for study in the STEM fields – by way of teachers who neglect to serve as the main stimulus producer in the classroom and fail to engage students in feedback conversations.

Feedback Effect

> "Formative assessment does make a difference, and it is the quality, not just the quantity, of feedback that merits our closest attention. By quality of feedback, we now realize we have to understand not just the technical structure of the feedback (such as accuracy, comprehensiveness and appropriateness) but also its accessibility to the learner (as a communication), its catalytic and coaching value, and its ability to inspire confidence and hope." (Sadler, 1998, p. 84)

Motivation. "Classroom evaluation affects students in many different ways. For instance, it guides their judgement[sic] of what is important to learn, affects their motivation and self-perceptions of competence…." (Crooks, 1988, p.467).

Ruth Butler (1988) evidenced the motivational effect of feedback through an experiment conducted with 11-year-old, Israeli students. In three different sessions, students completed written tasks on their own and then received one of three types of feedback: written comments that specifically targeted how well the student had addressed the objectives, only grades that were constructed from previous work, or both grades and tailored written comments. Butler (1988) found that feedback related to the task and not to student ego led to greater learning benefit. Students who received comments alone made consistent and significant gains throughout different phases of the experiment while those students who

received a grade, with or without comments, did not continually improve. Explained this way, a judgment, such as a grade, focuses attention on the ego aspect of the outcome and offers no insight into how to improve. Students who received comments along with a grade focused entirely on the grade and overlooked the comments.

Butler and Winne (1995) conducted motivation and feedback research and suggest that student perception or belief is a factor that impacts effect. Students bring to the experience of learning initial qualities that are compiled from "interests, goals, degree of self-efficacy, and degree of prior relevant knowledge" (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991, p. 231). Student beliefs about how much effort it takes to succeed, what it means to learn and how unambiguous an answer should be have been found to significantly affect learning outcomes. This research suggests that the power of feedback can be improved by considering the message communicated and the goal that the message supports. Meanwhile, feedback leads to an adjustment in what students come to know and understand and of motivation and self-efficacy. In their meta-analysis, Bangert-Drowns et al. (1991) discovered that feedback was not effective always and could even lead to negative outcomes. A few of the interesting findings regarding students' perceptions and goals of learning from this meta-analysis are:

- Pretests significantly lower feedback effect sizes because pretests focus the learner's attention on simple facts.
- Feedback used in computer based learning is less effective because learning goals are generally very simple, fact retrieval-type tasks that do not involve deep learning or reasoning.

- Feedback is most effective when the conditions that surround it encourage "mindful reception" (p. 233).

To utilize information as feedback students need understand different information that is shared during a task, remember features of the task when feedback about the task is communicated, and have strategies available to generate effective internal feedback. Students who use strategies and generate effective internal feedback are self-regulating and they are using error-detection. Self-regulation can be taught (White & Frederiksen, 1998, 2005). And for students to learn to self-regulate, scaffolded experiences during feedback conversations are needed where teachers model what reasoning looks like, how information becomes feedback and error detection. Great misunderstandings between teachers and students regarding their roles during classroom conversations — who should ask the questions and who holds the information – is a point identified by many throughout the educational literature including motivation and goal theorists.

This idea of motivation and goals has been explored over time. The German psychologist, Ebbinghaus, born in 1850, (as explored by Hoffman et al., 1987) led in the field of research on verbal memory, learning and attention. Even in 1885 he identified a motivational component in understanding higher mental processes. He wrote:

> "If by any chance a deeper penetration of this matter should present itself, surely, considering the significance of memory for all its mental phenomena, it should be our wish to en

> ter that path at once. For at the very worse, we should prefer to see resignation arise from the failure of earnest investigations rather than from persistent, helpless astonishment in the face of their difficulties." Ebbinghaus (1885).

Inquiry has been documented as an affective teaching strategy for addressing student misconceptions in science and mathematics (Dewey, 1910; Piaget, 1970; Driver, 1994; Anderson, 1998; Burkam, Lee, & Smerdon, 1997; Glasson, 1989; Lee, Chen, & Smerdon, 1996; White & Frederiksen, 2005). And reasoning is a type of inquiry learning that has been shown to be an effective strategy for improving conceptual understanding in math and science (National Research Council, NCTM, et al.). When teacher or students demonstrate inquiry thinking within feedback conversations, reasoning is present.

Wang (2008) discovered that teachers have deeply entrenched motivations the prevent them from changing their teaching practices. During a three-phase teacher education program developed to address this dilemma, in the second phase, the activity of watching a video example and participating in a reflective class discussion, progress was made in changing the perceptions of student teachers. SchÖn (1983) recognizes that the work of teachers is extremely complex and requires deep reflection. I contend that reflection is scaffolded by both teacher and student during feedback conversations, part of a process of co-constructing goals and renegotiating goal orientations.

Goals and orientation. Goal orientation which has been conceptualized in many

ways, learning vs. performance goals (Schunk, 1996), task vs. ego goals (Butler, 1988), mastery vs. performance goals (Ames & Archer, 1988) and process vs. product goals (Schunk & Swartz, 1993a) has been shown to be communicated through feedback and related to learning outcomes (Butler, 1987, 1988; Hattie & Timperley, 2007; Mory, 1994). Teachers can impact the goal orientations of their students (Pintrich, 1993; Zimmerman, 1989).

Another way that goal orientation has been identified is through task orientation vs. ego orientation (Butler, 1988). In this case, learning is advanced when the focus is on the process or what is learned while accomplishing the task. The opposite orientation, ego orientation, supports learning when the self is recognized. An example of a feedback that is considered task oriented would be tailored comments that tie performance directly back to the learning objectives. Feedback that is considered ego oriented personally addresses characteristics of the learner and no new information is shared that might be used to improve the learning outcome or task such as “nice job” and “good boy”.

In representing goal orientation as mastery vs. performance (Ames & Archer, 1988) the difference may be in the degree of quality. Mastery orientation relates to the desire of the learner to do well for the sake of it and attributes success to effort and positive attitude. Performance orientation, on the other hand, credits learning improvement to relative ability, little effort and out-performing other students.

Similarly, process vs. product orientation (Schunk & Swartz, 1993a) captures the difference of focus from how things happen to simply that they happened at all. Product

orientation leaves little room for concern about quality, process or metacognitive development.

The goals that students (and teachers) have can be immediate or last over time, serving the learning now and in the future. Goals are shared and negotiated within teacher feedback conversations and identified in the educational literature as learning vs. performance goals (Schunk, 1996), task vs. ego goals (Butler, 1988), mastery vs. performance goals (Ames & Archer, 1988) and process vs. product goals (Schunk & Swartz, 1993a). At the same time, feedback has been identified as a mechanism for improving student motivation (Bandura, 1977). Black & Wiliam (1998) found that in P-12 classrooms, feedback evaluations were centered around goals of rote learning and not on deeper understanding with teachers deeply engrained in certain practices and unable to adopt new roles within feedback and that students require a sense of self-worth in order to engage and turn information into feedback.

Feedback exposes the learning objectives of the teacher including the degree to which a teacher feels the need to provide the answer when a student is uncertain. A teacher who readily provides the answer is driven by teacher-centered goals. When a teacher is able to resist the temptation to turn a feedback event into a didactic experience, the teacher's objective is student-driven. This concept applies equally well to detecting student objectives and the degree to which a student expects the teacher to provide the correct answer when they are stuck. Teachers have different goals or objectives for their students and different

motivations that are the fuel for these objectives or goals, for motivation and goal are inextricably intertwined (Pintrich, 1993) and understanding motivation depends on understanding the specific goals of individuals (Nolen, 1988; Ames, 1984; Asch, 1952; Crutchfield, 1962; Dweck, 1985; Maehr, 1983; Maehr & Braskamp, 1986; Nicholls, 1984; Spence & Helmreich, 1983).

In the study of feedback and learning, it is important to look for the goals of teachers and student beyond what has been identified by way or content of learning objectives. The goals of teachers and students underscore and reveal the type of learning or performance that is expected and valued (Pintrich et al., 1993; Quynn, 2008; Strike & Posner, 1992). Understanding students and teacher goals in specifics has been used to explain learning and considered vital to explaining how learning works. I borrow from motivation and goal theory to suggest that knowing the degree to which teachers engage students in feedback conversations explains how much value teachers place in their feedback and what prevents feedback. Elawar (1984) discovered that giving student personal tailored feedback resulted in a better attitude toward math and higher achievement, regardless of student ability. This feedback was given in written form and teacher participants reported that the process of giving tailored written comments was arduous so that they could not guarantee they would continue the practice at the close of the study.

Students can be intrinsically motivated and can learn regardless of interaction or engagement. Within this dissertation, “relationship” is seen as a type of scaffolding which leverages an environment of greater participation for students because it widens their capacity

to engage in the learning process (Goos 2004) and feedback conversations improve intrinsic motivation by reducing the gap between actual and potential learner sense of self-worth. Feedback conversations allow for information to be exchanged and experiences to contribute to student understanding of self-worth as a type of learning in the class.

Renegotiation of goals between teacher and student. The formative assessment practice that a teacher develops can be easily distinguished from summative tasks by intention or goal (Sadler, 1989) and goals must be considered as system parameters for which there are two original levels, teacher goal and students goal, and a gap exists between the two (Sadler, 1989). What leads to conceptual understanding between these two parties is a steady renegotiation of these levels between teacher and student throughout the learning experience. This renegotiation impacts the type of and level of motivation available in the system.

A student goal is what the student wants to do and what is important to the student to accomplish (or not accomplish). It reflects past learning experiences, achievement level, home expectations, intrinsic and extrinsic motivations and self-efficacy. Teacher goal is what the teacher wants/expects the student to do. It reflects training and knowledge particularly with regard to what it means to learn science and math and how professionals in STEM fields use science and math, as well as past experience, and self-efficacy (Thomas & Oldfather, 1997). Conceptual change is one example of learning that can occur because of motivation or relationship. It is possible to refine conceptual ideas without relationship or void of any social encounter, but it is more common for learners to reach new understandings because they are engaged in a relationship that is the result of a variety of interactions.

In classrooms, teachers have goals or benchmarks for their students and these vary greatly by individuals and can include procedural and conceptual learning goals, goals that are social (e.g., making friends, working well in a group), motivational (Pintrich, 1993), or geared toward self-efficacy (Bandura, 1977). I take the position that the most important goal a teacher can adopt is in reducing the gap that students feel between their actual contribution as a learner and what is possible. Teachers can reduce this gap by the way they craft their feedback conversations.

Feedback as interaction. Research that explores how gaps are impacted through formative assessment to improve instruction and learning (Bailey & Jakicic, 2012; Bloom, 1969; Brookhart, 2009; Scriven, 1967; Wiliam, 2011) presents feedback as in interactive process involving both teacher and student (Chin, 2006; Bell & Cowie, 2000). "The feedback or dialogue is seen as an essential component of formative assessment interaction where the intention is to support learning" (Bell & Cowie, 2000, p. 539). For the purpose of this paper, feedback comes in the form of an interactive conversation between teacher and student. As well, students who are most successful are involved in a process of self-assessment, something found to be necessary for student success (Pintrich & DeGroot, 1990) and something that is modeled for students by their teachers during classroom conversations or feedback interactions (Bandura, 1977).

> Central to this theory is the mutually constitutive relationship between the collective and the individual that occurs as learners and more expert participants together engage in joint activities. In this context, children are

> introduced to new patterns of thought that are mediated by the use of cultural tools such as spoken and written language and, as they engage in interaction with peers and adults, they construct their own understanding by appropriating the cognitive processes that are manifested in the dialogue.
> (Heneda, 1999, p. 461).

Students learn through interaction with their teacher — the expert — and these interactions are critical to the development of relationships. Forman, Minick and Stone (1993) agree that thinking is greatly linked to interpersonal relationships and to context because modes of thinking are related to forms of social practice. Many who study how learning occurs ground their empirical work in the theory of socioculturalism and choose the unit of analysis to be the interaction between teacher and student (Jones and Gerig 1994; Crawford, Krajcik et al. 1999; Hogan, Nastasi et al. 1999; McGonigal 1999; Kovalainen, Kumpulainen et al. 2001; Khine and Fisher 2003; Rasku-Puttonen, Etelapelto et al. 2003; Cornelius and Herrenkohl 2004; Rapp 2005; Wu and Krajcik 2006; Wang and Lin 2008).

For example, research on teacher-student interactions that lead to conceptual change in science inquiry environments reveal qualities of teacher participation that correlate with progress in student thinking (Chin, 2006; Driver, et al., 1994; White & Frederiksen, 2005). Ways in which a teacher participates in the conceptual refinement of student thinking include what a teacher does to scaffold student understanding. Teacher scaffolding has been identified as a process that allows novice learners to participate in activities and build understandings

that otherwise would be out of reach. Research findings suggest that students who make learning progress interact with teachers who know how to scaffold in situ and create classroom conditions that require more, not less, student participation and teachers leverage greater student participation and interaction (Bransford et al., 2000; Goos, 2004). It is this type of leveraging that I intend to detect in feedback conversations that reduce the gap between actual and potential learner self-worth.

Teachers who understand how to build scaffolds, uniquely and creatively, are sharing with their students more than an affinity for helping, but are introducing a new experience by way of a new epistemological understanding regarding what it means to learn, to be a mathematician, a scientist or an engineer, and that learning is interaction. Specifically, Goos (2004) reports that these teachers encourage argumentation, which, in feedback, could be identified as critical position, use student ideas as starting points for discussion, and use questioning to elicit student thinking.

Feedback as an interactive loop. Research by Bangert-Drowns et al. (1991), presented feedback as a loop and not a unidirectional force (Bell & Cowie, 2000). It is the feedback from teacher to student that allows student to gage progress and redirect their thinking and feedback from student to teacher that allows teacher to detect misconceptions, retool teaching strategies, and create more opportunities for interaction – second chances to express understanding and deepen perspective. In a well-honed feedback loop, teachers redirect their teaching because of the feedback they receive from their students. In this case, the assessment is purely formative because it involves both teacher and student.

Theories of communication processes (Watzlawick et al., 1967) are naturally related to timeliness where an event becomes a cycle of smaller, reactive moves — the response of one person is the result of the behavior or response of the other before which goes on to influence the first and back and forth and on and on. Again, it is a loop. This model explains what happens in teacher-student interactions; the thinking and behavior of a teacher is the result of student thinking or action which then influences the student's next idea or move. All of these moves work together to construct meaning and to close the gap between actual and potential self-worth for the learner.

Every aspect of an interaction has the potential to become feedback, informing an understanding of the relationship between those involved. Students gain information about many different things during an interaction with a teacher. They learn about how patient their teacher is, how much their teacher enjoys the subject and being challenged by new problems, what motivates their teacher and the goals their teacher holds for them. These are qualities of the interaction that impact the gap between actual and potential learner self-worth.

Roles and power. To understand feedback qualities as an interaction, it is important to recognize what teachers and students do during it or the roles they take on during classroom interactions. Teacher can act as administrator during feedback events, e.g., as when "evaluative listening" (Davis, 1997), asking all the questions and placing the student strictly in the role of responder or the one being evaluated. Instead, if roles are less distinct because they are being assumed or shared jointly by teacher and student, the feedback interaction gives student a broader experience. It becomes increasingly formative the greater variety of

experiences student has during feedback interactions. When teachers share roles within feedback conversations with their students, they are sharing the job with the student and are promoting value for the student. Sadler writes that “unless learners are insiders who share the evaluative schemata of the connoisseur-teacher, they are mere consumers of evaluations and have no alternative but to rely on the authority and competence of the judge” (Sadler, 1983, p. 68).

In a study of 6th graders, observed and interviewed during the course of a science unit, researchers examined classroom interactions and focused upon changes in authority or power(Cornelius and Herrenkohl 2004). The research questions revolved around how participant structures, as any “cultural tool”(Wertsch 1985), affect power relationships between peers and between student and teacher. Findings suggest that participant structures impact classroom roles and relationships and that “persuasive discourse created a new relationship of power among the students as well as fellow classmates and the teacher became monitor of the ideas espoused by the focus students and served to balance their power” (Cornelius & Herrenkohl, 2004, p. 492).

Enyedy and Goldberg (2004) used a framework to look deeper than the scientific quality of teacher talk, and instead to examine how teachers support or discourage opportunities to learn and the epistemic nature of what might be learned and how. They found that power in learning communities is dynamic, teachers’ roles change, there is a process of constant negotiation for power and that learning communities establish norms for participation. The study involved comparing the interactions of two teachers with different

goal orientations, one more inquiry driven than the other. Students in the more inquiry oriented classroom had significantly higher mean gain scores on the assessment that measured learning. Further analysis of interactions concluded that the different goal orientations led to greater variability in the classroom environments and this is what impacts student outcomes. This study suggests that understanding teacher goals is vital to understanding what is in a teacher-student interaction.

Kovalainen et al. (2001), added to early work by John Dewey (1902, 1916, 1963) and democratic classroom environments and more recent theory of Brown et al. (Brown & Campione, 1990; Brown, Campione, Reeve, Ferrara, & Palinscar, 1991) and the practice of reciprocal teaching Kovalainen et al. (2001) found that teacher-student interactions have four modes of teacher participation in discourse which are evocative (ask stimulating questions), facilitative (provide students support to extend thinking, revoicing and sharing established knowledge), collective (promote social and emotional processes such as inclusion), and appreciative (communicate genuine interest in students' ideas, foster self-esteem).

In feedback, teachers play different roles in order to construct a new experience and new information with a student. Teachers who understand that their students construct knowledge as individuals refrain from consistently *telling* their students what is missing in their understanding, often an indicator of teacher self-discipline and willingness to take on a backseat role that allows students to present their own ideas (Schwartz & Bransford, 1998; Hogan, Nastasi et al. 1999). The degree to which teachers are willing to switch roles from information holder to information seeker during feedback events demonstrates sensitivity to

students who are involved in constructing their own knowledge, developing their sense of self-worth as a learner.

Although I reduce the information within feedback moves by teacher and student to rote vs. reasoning, there are many types of feedback messages communicated to students that have been considered. In a study of 6th and 7th year olds, McGonigal (1999), a classroom teacher and researcher removed all desks from the classroom to create a climate without authority and to present classroom learning as fully collaborative between students and teacher. The teacher-researcher was sending her students a message regarding her values for a learning environment, what she believed students need to be successful learners, and her willingness to assume a new role from traditional teachers to that end. Teachers (and students) communicate information in a variety of ways, including written comments made on student work, body language (rolling of the eyes is full of information) and physical choices they make in their classroom regarding material setup (desk arrangement, types of desks, issues regarding accessibility) and even in their proximity to their students. Any information can impact student engagement, however my focus is on individual interactions that teachers and students have and what can be learned about student experience form these feedback conversations.

Feedback and teacher responsibility. The key ingredient of formative feedback can be seen as a formative loop (Sadler, 1989) in which information is delivered between teacher and student, by teacher and student during a feedback event. Because the main interest of this dissertation study is in understanding feedback as it relates to how students feel about

themselves as learners or their self-worth, I place the teacher as responsible for the level of self-worth that students adopt while learning in their classroom by way of the degree to which students engage in learning and feel that they can affect their own leaning experience. Fatalistic teachers will build a weak feedback practice that is not interactive and not formative – they do not believe in the power of their feedback to impact learner self-worth. Although I could not find any studies that document the degree to which teachers believe in the effectiveness of their feedback practice, the literature shows that teachers underutilize feedback and thus, do not take advantage of its power in classroom instruction (Black & Wiliam, 1998a & 1998b).

However, teachers have little to go on when it comes to understanding their feedback practice. In addition, research is often based upon "contrived experimental learning situations" (Mory, 2003, p. 745) that focus efforts on very particular aspects of feedback and offer no way to understand what matters in the overall feedback practice of a classroom teacher. The traditional experimental approach to understanding feedback has resulted in research findings that seem inconsistent, and not complementary in any coherent and meaningful way (Mory, 2004; Hattie & Timperley, 2007; Shute, 2008; Black & Wiliam, 2009). I share this concern about earlier research studies and their inability to advise the classroom teacher on what makes for an effective feedback practice. Classroom teachers do not have reliable and feasible methods for understanding their own feedback habits, to reflect and make informed changes based on what they learn. For the field practitioner, rather than study isolated qualities of feedback, this study intends to understand the feedback habits and

general practice of the classroom teacher, the aggregate of all feedback conversations that occur between teacher and student.

Feedback and Engagement

> We learn much of what we know by observing and practicing in situ the behavior of members of cultures, the language and idioms they use, and the way they frame daily events.
>
> Roth & Roth, 1995, p. 73

Learning as doing. Research has distinguished learning in different ways, but most often it is detected in terms of the complexity of a task (Hogan & Nastasi et al. (1999). Harlen & James (1997) differentiate learning as "rote" or "real", with real learning "actively understood and internalised[sic] by the learner" (Harlen & James, 1997, p. 369). Schwartz and Bransford (1998) identify expert learning as "deep learning" (p.506) and detectable when knowledge is differentiated. Learning can be a simple event or an experience that requires many mental operations and evokes new thinking or new application of old thinking or reasoning. Reasoning is a type of involvement; it is a doing thing beyond memorization or the recall of rote knowledge.

In this study, feedback is seen as the engagement of teacher and student in conversation. The term loop has been used by Sadler (1989) to describe "setting a learning goal, determining the gap between the learning goal and the student's present state of understanding, and formulating feedback to close the gap" (Furtak, 2006, p. 4). However, I reuse the term *feedback loop* to emphasize a conversation that is interactive, formative and

crafted by alternating teacher and student moves[8] (Chin, 2006). And again, these reasoning moves are *doing things*. Conversations are loops of interactive experiences and teachers can craft interactions to support students to reach deep learning and arrive at something new. Teacher feedback conversations that are complex allow for new, unpredictable understandings to be formed that are the produce of many mental operations. In these more complex conversations, deep learning is evident when reasoning happens. The common thread for all higher forms of learning is prolonged mental activity; students are not the receiver of learning, not the vessel from which learning is contained and drawn forth, but rather, students are engaged in the creation of the learning.

Feedback experiences to engage students. Current views explain learning as actively constructed (e.g. Bransford, 2000) where teachers provide experiences and guidance that scaffold the construction (Vygotsky, 1978). There are many sources that might be considered feedback because they lead to new understanding, such as a book, a peer or the sky (Hattie & Timpreley, 2007). Learners can initiate feedback opportunities to seek out or create feedback to test a hypothesis they have and then move on to a better theory (Thomas & Oldfather, 1997). However, for most students, looking in a book or at the sky are not the "sufficiently salient" (Bandura, 1977, p.22) experiences that lead to "deep learning" (Schwartz and Bransford, 1998, p. 506). Teachers are the salient stimuli students require to become engaged in the learning process and this takes the form of feedback conversations. A feedback conversation that involved constructed, new knowledge or that involves reasoning signals that

[8] See Chin (2006) for a historical review on the meaning of "moves" in teacher-student interactions.

deeper learning is taking place. Reasoning could be split in different ways, examined in more detail so to become a multi-dimensional construct needing different outcome measures, such as schematic and strategic knowledge (Li, 2001; Li, Ruiz-Primo, & Shavelson, 2006; Shavelson & Ruiz-Primo, 1999; Ruiz-Primo, 1997, 1998, 2002). However, for the purpose of this dissertation study, I use a didactic approach to document whether or not reasoning happens during a feedback conversation.

Reasoning detected in feedback conversations is evidence that the conversation is not evaluative. Rodgers (2006) attempts to separate descriptive feedback from reasoning or construction of knowledge, however in my mind, I cannot do this. I suggest instead that when students reflect and describe their thinking, they are constructing knowledge and this involvement is "… a process through which they find out about their learning" (Bell & Cowie, 2000) and when students describe their thinking to a teacher, they are reasoning and knowledge is new and constructed. All learning is not conceptual learning, related to state standards, classroom learning targets, or task to be completed. Learning can be a new way for a student to see himself, about *value* as a learner *of* the content.

Certainly for many students, in order to engage in feedback conversations and reduce the gap between actual and potential learner self-worth, they need an invitation by the teacher as main stimulus maker. They will need to share in a critique of their experience within the evaluation process (Sadler, 1983). Teachers are responsible for student invitations into feedback conversations, and for creating the conditions that lead students to participate in their own learning and in understanding their thinking as reasoned engagement.

Student Factors and Contribution

Butler and Winne (1995) have extensively reviewed motivation and feedback literatures to suggest that student beliefs and goals impact learning. Students can have goals that are very much at odds with their teacher, e.g. a student who want only to finish quickly and get a prize may find the goal incongruent to a teacher's goal of mastery that involves assessing student work at the individual level, asking for revision and resubmission. When teachers can see their students as individuals with unique goals, understandings and questions, and levels of self-worth they can respond to these within feedback conversations and create experiences of value for students within their feedback practice. Within conversations, teachers can develop opportunities for students to share their understandings. Mainly, this study entertains my interest in understanding the feedback practice of teachers by qualities, but also in terms of how they distribute feedback within a lesson and provide students equitable opportunities to reason through new ideas and impact the gap they are experiencing between actual and potential self-worth. How teachers distribute feedback indicates their understanding of it as a powerful force and their interest in understanding experience for all of their students.

It has been found that how people think is influenced by situations, previous knowledge, experiences, feelings and interactions with others. And that learning is an individual process related to how people learn concepts and solve problems (Ausubel, 1963; Bruner, Boodnow & Austin, 1956). Students construct their knowledge in situations, and as individuals, there is then an element of student in feedback effect. Kulhavy, Yekovich, &

Dyer (1976) showed that student confidence in a response influenced the effect of feedback on future retention and that feedback is most effective when students report high confidence in a response only to realize they were incorrect in their thinking OR when subjects lack confidence in a response only to learn that they had it right. Under these conditions (high confidence and incorrect response or low confidence and correct response) subjects spend more time reviewing feedback which explains their improvement in retention. It is the extra interest of the student that turns information into feedback.

These research findings show that the student factor *confidence* plays a pivotal role in how information is used by students. Certainly confidence is related to level of self-worth a student feels in the class. Within this understanding of the student factors on feedback effect, I suggest that students engage because they have higher confidence in themselves which is impacted through engagement with the teacher.

Student and self. The focus of this dissertation is on teacher feedback and the gap between actual and potential value that a student feels as a learner of science or math. Student factors play a role in the effectiveness of feedback (Kulhavy, Yekovich, & Dyer, 1976), however research is limited in the area of understanding student factors. Self-efficacy has been used to explain the differences in individual learners (Bandura, 1989; Butler & Winne, 1989) as well as confidence (Kulhavy, Yekovich, & Dyer, 1976) where confidence may be used to indicate something momentary and easily changed. Self-worth, as used repeatedly in this study, is used to convey a belief that a student has in himself to participate in the learning process and contribute, to make information useful and it is an indication of how invested a

student is in the learning process. A student who is invested in the learning engages and enjoys a certain confidence regarding what it is that they need to know or do to improve. Students who experience a high level of self-worth feel empowered to learn and are more likely initiate feedback conversations with their teachers, feel at home when critical positions are expressed and self-regulate. They have greater confidence in their own ideas and in their work product.

I take a position that student self-worth is the student factor that matters when identifying the feedback practice of teacher in terms of qualities and distribution. For if students at the highest and lowest levels of confidence or self-worth are most impacted by feedback, how then is feedback crafted? Does it reflect this? Is it carefully designed to match students based on their level of self-worth in the classroom, to nudge and encourage a closing of the gap? My position is that feedback must be crafted to the need of the individual learner and if it is to be effective in closing the gap between actual and potential levels of learner self-worth, teachers must do this by way of feedback conversation qualities and distribution. How does a teacher impact the self-worth of a student? By involving them in the formative process of feedback, listening and engaging and sharing roles that provide the student a new experience and new opportunity consider their value as a learner.

Student score as student factor. Student score or grade in the class has been identified in the literature as more than a measure of student achievement in classroom learning (Thomas & Oldfather, 1997; Deci & Ryan, 1987b; Kohn, 1993; Wiggins, 1993; Oldfather & Dahl, 1994; Oldfather & McLaughlin, 1993; Oldfather and Thomas, 1996a). And

the way in which students construct their understanding of themselves is crucial to the outcome of their motivation to learn and how they learn in the future (Thomas & Oldfather, 1997). Grades are strong messages "that have consequences for students' actions; for their concepts of themselves as learners….and for their intrinsic interest…." (Thomas & Oldfather, 1997, p. 198).

In this dissertation study, the overall student score in the class is considered a valid measure (not to be confused with an invalid academic measure), of student sense of self-worth or value as a learner of the subject. Students with high overall score in the class enjoy a high level of self-worth and belief that they have something to contribute to the learning process. Students with low overall scores in the class believe that they do not. The score, or grade, in science is used as an indicator of the confidence a student has in their contribution as a learner or sense of self-worth they feel as a science or math learner (Thomas & Oldfather, 1997).

It has been shown that feedback effect is dependent on student factors (Kulhavy, Yekovich, & Dyer, 1976), and so from this it is reasonable to say that teacher feedback, in terms of qualities, will not look the same for every student. But how will these qualities differ for students in terms of their overall score in the class?

Student perception of teacher. Researchers Khine & Fisher (2003) administered the Questionnaire on Teacher Interaction (QTI) to students in the U.S., Australia, Korea, Singapore, Brunei and the Netherlands based on the theoretical link between classroom interactions, student attitude and learning through inquiry or reasoning. In this survey, students responded to statements such as "if we don't agree with this teacher, we can talk

about it", "we can influence this teacher", "this teacher seems uncertain" and "this teacher thinks that we don't know anything". A strong association was found between students' perceptions of teacher-student interactions and student achievement. Researchers concluded that "teacher-student interaction has become a potentially powerful determinant of student learning" (p. 27). Student perceptions of classroom environment, formed through interaction with their teacher are strongly related to achievement (Haertel et al., 1981).

In developing a tool for measuring students' perceptions of teacher-student interactions and students' inquiry skills, Fisher & Waldrip (1999) detected a mismatch of goal orientations between home and school. They identified the importance of understanding cultural conflicts that occur between home and classroom in trying to understand the relationship between culturally sensitive factors of a learning environment and the school practices involved in learning science. A survey was administered to more than 3000 secondary science students in Australia that found it possible to detect a difference in classroom environments by teacher and by learning type, rote learning vs. reasoned learning. Classroom environment was found distinguishable by students' perception of teacher, teachers gained respect from students as they afforded students more responsibility, in classrooms where teachers played an authoritarian role there was less reasoning. And from these findings, teachers must consider different cultures and goal orientations of learners and the way in which students perceive their learning environment for it all has an effect on learning outcome and achievement.

Student self-regulation and reflection.

‘Reflection is always more or less troublesome because it involves overcoming the inertia that inclines one to accept suggestions at their face value; it involves willingness to endure a condition of mental unrest and disturbance.” John Dewey, 1910, p. 13

Butler & Winne (1995) contribute a crucial new perspective on feedback as a mechanism for promoting reflection and self-regulated learning, as activity that distinguishes expert from novice learners. Students who practice self-regulation set goals for upgrading their understanding carefully consider different strategies based on their goals and unwanted costs, and continually monitor their contribution throughout the task. Those who are self-regulated often trade goals during a task, take an active role in managing their motivation, adapt and create tactics to continue to move forward in the learning process. They are continually monitoring their knowledge, beliefs, motivations and cognitive processes, are engaged in understanding how their cognitive activity meets the standards that they set for themselves and seek out feedback that serves their goals. Butler & Winne (1995) set feedback within a model of self-regulation, because self-regulation leads to a change in understanding. They concern themselves with affect and how it relates to persistence in self-regulated feedback during decision making, as well as student belief systems on learning and how these factors contribute to conceptual growth. If feedback is to promote self-regulation and improve achievement, it must impact and address the types of goals students hold and affect the

processes they use to prioritize, select and protect or revise their goals. Therefore, feedback should provide more than just domain information, but should speak to the current goals of students. Self-regulation is required to achieve (Pintrich & DeGroot, 1990).

Summary of the Literatures

Black & Wiliam (1998) synthesized the results of 250 empirical studies and found that feedback: 1) has the greatest impact of any other classroom intervention in terms of improving learning for *all* students, 2) relates to teacher and student interactions, 3) is most effective when it is timely, and 4) allows the goals of teacher and student to be communicated and negotiated. Based on the reviewed literature, my definition of feedback as a conversation that takes place between teacher and student, reducing the gap between actual and potential feeling of self-worth for the learner: 1) must be timely (as all good conversations), 2) is an interaction allowing for teacher or student to initiate the exchange, share roles and goals, 3) present new information, and 4) allows for error detection and critical positions to be heard. These ideas can be reduced to feedback conversations are timely, information sharing opportunities that motivate students to look at themselves in new ways. Feedback conversations that allow a student to experience a new role beyond simply the recipient of feedback or as the one controlled during an evaluative process (Wiliam, 2011) provide new student experiences that lead to the construction of new understandings of how they feel about themselves as a learner or self-worth, as a contributor to the field now and in the future.

The power of feedback has been identified throughout the educational literature, however it was found to be underutilized in classroom instruction (Black & Wiliam, 1989a

and 1989b). My explanation for this is that feedback is too often accessed by teachers in relation to content and process instruction as these relates to lesson objectives and short term learning goals. There is needed a new method for detecting when teachers underutilize their feedback practice in terms of how they craft feedback conversations and how they distribute these to students. As of yet, the research literature holds very few opportunities to see how this could be done.

Feedback has been identified as a loop (Sadler, 1989) that engages both students and teacher and that feeds back into the learning process, allowing teachers to monitor learning, determine if re-teaching is necessary or if it is time to move on (Sadler, 1989; Tunstall & Gipps, 1996). Information students use to then improve achievement as well as information that teachers use to improve teaching performance is feedback. I maintain learning as engagement and so my main interest is in understanding how teachers distribute their feedback to engage students within their practice. I am interested in understanding how students react to teacher feedback and how likely they are as individuals to initiate feedback with their teacher.

Chapter 3: Method

Overview

The focus of this study is on teacher feedback and student experience with teacher feedback. This research dissertation is an inquiry into understanding, coding and measuring the qualities of a teacher's feedback practice so to understand how teacher feedback relates to student score in the class as an indicator of student self-efficacy or sense of self-worth as a science learner. Within this chapter, the process used for collecting and analyzing classroom feedback data in order to better understand the relationship between teacher feedback and student score is detailed. This chapter, *Method*, provides description of the process of data collection that can be seen as a tool teachers can use to better examine their own feedback practice, and with the help of data, make new feedback decisions that will lead to different interaction patterns in their feedback practice and improve their effectiveness, student engagement and learning.

Unit of Analysis

For this dissertation study, *teacher feedback practice* is operationalized as the aggregate of all individual feedback events that happen during classroom instruction. The feedback experience of a single student is the collection of all feedback events that they are involved in during classroom instructional time. The unit of interest or unit of analysis is *feedback event*, which is defined simply as a communication or conversation between a teacher and one student. Each feedback event is represented as a node (*see Figure 3.1*).

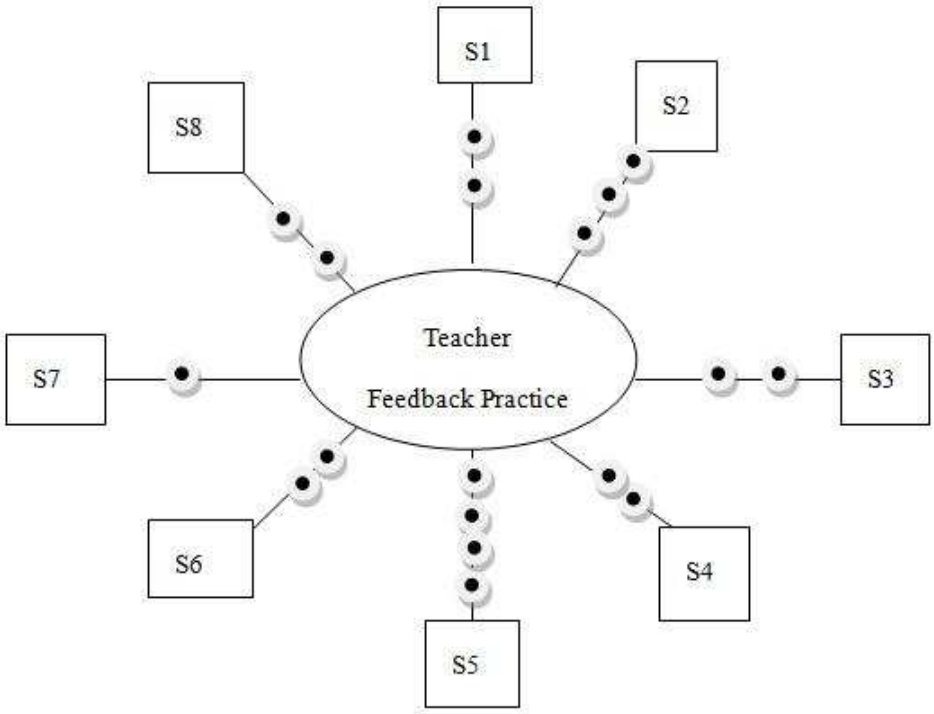

Figure 3.1 Conceptualization of feedback events, teacher feedback practice student experience within the practice.

Teacher nodes sit on a line drawn between teacher and student, representing the experiences they share. The culmination of all nodes represents the teacher's feedback practice. *(see Figure 3.1)*. The teacher, who is primarily of interest in this dissertation study, is involved in every feedback event, communication or interaction – as they have been defined – and navigates from one student to another, adapting to a new student idea, statement or question or prompting a feedback event by asking a student a question.

Every communication or feedback event is considered a unique and individual experience shared by teacher and student that contains information that can be identified and

coded. By tallying up frequencies of these identifiers, claims can be made about how often certain things occur within a teacher's feedback practice and how these relate to a student's experience within that feedback practice. The task within this dissertation is to reliably code feedback events and accurately identify the student participant involved in each event. Doing this well, or reliably, will set the stage for meaningful information to emerge about the feedback practice that a classroom teacher has structured, allowing for comparisons to be made between teacher practices and for understanding the different experiences that students have with teacher feedback during classroom instruction.

For this study, a feedback event or communication involves only the teacher and a single student. Because this paper focuses on the individual experiences of students with teacher feedback, group communications that involve teacher and more than one student are divided into more than one event so to involve just one student. In each case, the primary student involved in the event is identified until another student becomes an active participant. When this happens, a new event has essentially started that involves a new student participant. The focus can just as easily move back to the original student, which marks the beginning of another feedback event.

Effective feedback is timely (Kulik & Kulik, 1988; Kulhavy and Yekovich 1976; Crooks 1988; Black and Wiliam 1998; Brookhart 2004), and so a teacher's feedback practice is made up of all timely feedback events that occur. This study is focused only on timely events or those events that take place within the lesson or that are in the moment, happening in real time and focused on the immediate interests and needs of the teacher and student. For

the reason of timeliness or immediacy of teacher feedback, written feedback is not coded or included in this study, however if written comments from a teacher prompts a conversation between teacher and student, then that interaction is what is coded as a feedback conversation because it takes place during the lesson.

Feedback events are measured for length or in number of moves (Chinn, 2006) with the shortest measured feedback event length consisting of one move. This occurs, for instance, when a teacher directs a student to do something and the student turns to do that thing, but does not verbally respond to the teacher's command. When the teacher passes back papers and calls out student names, this very short communication is considered a feedback event with a length of one (length 1). If a student were to respond to the teacher and say "thank you" or "okay", the feedback event becomes an event that is 2 moves in length. Another example of a feedback event of length one occurs when a student raises his hand and calls an answer out to the teacher and the teacher ignores the student comment.

Data Collection

Teachers, students and their parents consented to participate in this study and in the data collection that included digital video recording and the sharing of science scores. This study was designed to be minimally invasive and efficient and feasible for study participants.

The first step in data collection for this inquiry began with a search for a digital video camera that would produce a high quality audio recording. A digital camcorder with blue tooth technology was tested and found to minimize background noise and clearly capture the speakers' voices. During digital video recording the camera was placed in one corner of the

classroom and manually operated as often as possible to allow for following the teacher from student to student interaction. On a few occasions, the camera had to be left unattended and stationary. The results were not ideal because it produced a digital image that made it difficult for the rater to later identify the participating student with 100% confidence. Because this research focuses upon student feedback experiences, it was fundamental that student participant could be accurately identified in every feedback events.

The digital recording took place in fifteen total lessons across four participating teachers. For technical reasons such as microphone batteries failing, not all of the videos were worth coding. For this study, five consecutive lessons were chosen to be coded and analyzed. The lessons used were chosen because they 1) were of high quality in terms of audio and visual recording, (e.g., the microphone had battery power during the entire lesson and the camera followed students so that they could be identified during the coding process) and because they were lessons with a high rate of student attendance. For each teacher, there were at least two of the fifteen lessons in which the camera experienced technical problems. The two most common technical problems were low battery power in the microphone and a stationary camera that did not identify student speaker. In the second case it was nearly impossible for the raters to agree on which student was speaking during each of the feedback events.

In order to participate in this study, teachers, students and their parents provided written consent. Students also agreed to provide copies of third quarter report cards that included their score in science — the only other piece of data collected in addition to digital

video recording. Student science scores are determined by district-wide, grade-level assessments and are not influenced by learning goals of individual teachers.

In some educational research the definition of feedback has been constrained to information that relates only to the content being taught. For this dissertation, feedback is expanded to include information that relates to information that improves student motivation or sense of self-efficacy as well as content. Science score can be considered a measure of achievement in science as well as an indication of student self-efficacy or sense of self as a capable science learner.[9] Under the assumption that students want to do well in a class, scores are an indication of student success, but also, how a student feels about themselves as a learner in that class and a learner of that particular subject. From a teacher's perspective, feedback is a mechanism of comfort (Hattie, 2007) and can be a tool for leveraging higher self-efficacy from students who have low science scores.

Because this study seeks to understand how student score relates to student feedback experience, and not how students learn particular science concepts through feedback, data from students in different grade levels working on different science topics have been included in this study.

Study Participants

Data collection was carried out in the classrooms of four, middle school science teachers who work in the same science department, located in a large, suburban school district

[9] Another hypothesis is that science score is an indicator of how well a student likes the class which will be tested in future studies.

in the Pacific Northwest. The teachers, referred to as David, Becky, Tina and Monica, volunteered to participate in this research venture, sharing their teaching practice and allowing for digital video recording to happen over the course of fifteen lessons. For analysis, five consecutive lessons were chosen as a representative sample of normal teaching activity.

Teachers and teaching culture. In addition to data collected in the form of digitally recorded lessons and student scores in science, teachers shared ideas and information in thoughtful and unscripted conversations. Individually, these four teachers reported feeling fortunate to teach where they do and to work with the members of the science department. All of the teachers regularly consult and collaborate with their colleagues and each commented that they enjoy their school assignment, and in particular, the science department because of the high level of professional collaboration and strong personal bonds they have developed over 8 years of working together. All teachers reported receiving no professional development in the area of teacher feedback.

The teacher participants range in teaching experience from 8 to 17 years and consider themselves to be career educators who enthusiastically engage in professional development activities in order to be more effective educators. Three of the four teachers have received National Board Certification and the 4th, David, has been teaching for 17 years.

The members of this science department regularly meet and serve as professional resources and support for one another. Together, they applied for and received a grant that provides one day per month of professional development. On this day, one teacher volunteers to teach the lesson to a class of students while being observed by the other members of the

science department. Following they lesson, the team debriefs, sharing insights and making suggestions for improvement.

David, Becky, Tina, and Monica share a workroom between adjoining classrooms that they have warmly decorated with a faux electric fireplace, comfortable chairs and low lighting. It is regularly stocked with homemade baked goods. David, Becky, Tina, and Monica are highly regarded by the greater education and parent community because of their dedication, professional nature, and the contribution they consistently make to student achievement. Because the goal of this dissertation is to create a meaningful and accessible measurement tool for practitioners in the field, what is learned about the feedback practice of David, Becky, Tina, and Monica, a sample of four teachers, is not to be generalized to the greater population of middle school teachers. What is learned can be reflected upon by other teachers and administrators who are interested in improving learning by way of more equitable and effective teacher feedback practices.

Data used in these analyses were collected entirely through video tape and student report card. In order to measure typical feedback practice, teachers agreed to conduct their lessons as usual and made no changes in their instructional habits or performance. They also agreed that the lessons chosen for the analysis in this study are a good representation of what they do normally and of their feedback practice. This study appealed to these four teachers because it created no additional work for teachers who already experience full teaching plates and required them to change nothing about their instruction.

Teachers by experience and credentials. It is not possible in this dissertation to capture all of what is interesting about these four participating middle school teachers, but Table 3.2 documents professional highlights.

Name	*David*	*Becky*	*Tina*	*Monica*
Gender	Male	Female	Female	Female
Teaching Experience	17 years	8 years	8 years	7 years
Type of teaching certificate	4-12 grade, general science	4 - 12 grade, biology endorsement	K-8 general, 9 - 12 Marketing	4-12 grade math, general science and biology
National Board Certification	No	Yes - Early Adolescent Science	Yes - Early Adolescent Science	Yes - Early Adolescent Science
Grade Level	6^{th}	7^{th}	8^{th}	8^{th}
Unit Title	Genetics	Catastrophic Events	Physics/Speed	Physics/Speed

Table 3.1 Teacher characteristics

School context. The school district that employs David, Becky, Tina, and Monica provides lesson plan objectives and activities to all its teachers that they follow daily. The teachers receive these lesson plans via Internet and are also supplied science materials for hands-on learning experiences in kits prepared by district administrators. The participating

teachers also use interactive white boards, student response systems, and other instructional technologies and are required to fulfill professional development hours in courses offered by district administrators. What some would consider the tightening-of-the-reins by administrators regarding curricular decisions has led to a narrowing of teaching practice so that the lessons of students at the same grade level around the district is the same. Even so, teachers remain individuals who have unique understandings of what it means to learn. Their feedback practice is an indication of their unique understanding.

In addition to more narrow and focused curricular requirements, none of the teachers create their own student assessments. Assessments are written for them and required of them by their district administrators and are kept carefully guarded from the student and parent community. Students are not allowed to take tests and quizzes home because the test will be administered again the following year. The student score in science class is a result of these district-wide assessments and it is known by the student and the teacher who reports the score on quarterly report cards. In this dissertation, score in science is considered more than a measure of student learning or academic progress, but is also considered a measure of student status as a science learner or of self-efficacy.

Coding of Feedback Events

Video Data. Digital video data forms the corpus of data that were coded for this research. Raters (or coders) relied on audible audio from the digital camera recording in order to accurately apply coding rules to each feedback event while using the visual images captured by the camera to identify the student participant in each feedback event. This inquiry

seeks to understand feedback at the feedback event level, and to use this information to make claims about a teacher's feedback practice and the experiences of students within that practice. The relationships between a student's science score and the teacher's feedback interactions with that student were investigated through an analysis of feedback events. To accomplish this, it was necessary to code the feedback conversations of teachers, or feedback events in ways that accurately identified student and teacher. It wasn't difficult to identify the teacher, as that remained consistent throughout the lesson. The challenge at times was in identifying a particular student — a task made easier through careful camera operation (i.e., following and zooming in on the body of the student interacting with the teacher.) With participants in a feedback conversation identified, the moves of the conversation could be coded.

Coding rules. There are 5 ways in which teacher or student moves were coded. The moves were compiled to establish a code for an entire feedback event (*see Table 3.2*).

Teacher	Code	Explanation
	Tq	teacher question that students answer using "old" knowledge
	tq+	teacher question that requires student reasoning or "new thinking"
	Tr	teacher response that is factual or didactic
	tr+	teacher response that involves reasoning
	tr0	teacher response with no information such as "um", a placeholder
Student	Code	Explanation
	Sq	student question that does not elicit teacher reasoning
	sq+	student question that prompts teacher reasoning
	Sr	student response or statement without reasoning, didactic
	sr+	student response that involved reasoning
	sr0	student response with no new information such as "uh", a placeholder

Table 3.2 - Ten Codes with explanation

Coding example. In order to illustrate the coding process, an excerpt from a lesson in Monica's classroom is presented next. The topic at hand is the relationship between density, mass, and volume. The first column identifies the student, the second column contains a transcription of the feedback event, and the code for that feedback event is recorded in the third column. (The transcript is only included here for the purpose of demonstrating how coding rules apply, as this method for documenting does not require transcription.)[10] For the present study, feedback events or communications were reliably coded based on information captured in digital recordings that allowed for accurate identification of the participating student. Although coding can also be carried out by a trained observer in real time, eliminating the need for digital video recording, video data were important in this first application for the purpose of establishing inter-rater reliability.[11]

[10] Feedback mapping is a feasible one for it does not require transcription, a very time consuming practice in research that can become very expensive and not required for feedback mapping.

[11] Although feedback mapping can be done by a trained observer, in real time, it is recommended that video data be taken when possible, to allow coders to review scenes.

Student	Feedback event	Coding
Sarah	*Sarah…I don't want you to wear those…takes those off please.*	tr-
Pete	I was wondering, if, 'cuz for SS project, if I could go early and so I could set up?	sq
	Possibly, we'll see how you work today, OK?	tr, tq
	Ok	sr
Jan	*Thank you, Jan*	tr
John	*John, this just came for you.* (a note from the office)	tr
Sam	Is it ok, um, for your evidence, if I said I got I got it from my vocab. packet, is it ok if I have a picture example?	sq
	If you have a picture example, that will be ok. If you only say that you got it from your vocab. packet - that would not be enough.	tr
Lennie	*Lennie?*	tq
	10.	sr
Ella	*Ella?*	tq
	8	sr
Robert	*We only need to do the initial idea Robert. Just the initial idea Robert. Can you come in today for tutorial? Is that okay?*	tr tq
	Yes.	sr
Dakota	*Dakota did you do your idea journal?*	tq
	No	sr
	Can you come here today for tutorial?	tq
	Yes.	sr
Pete	*Peter? What about you?*	tq
	I didn't do it.	sr
	So, are you going to come here today for tutorial or homework center and get it done?	tq
	Yes.	sr
Becky	Um, I am not going to be here tomorrow.	sr
	Ok, you need to come today after school for tutorial. Okay?	tr, tq
	Okay.	sr
Robert	*Alright, so the first thing we are going to do today is finish up our lab investigation. What were the two different methods we were doing to try and find the volume of a cube? Robert?*	tr tq
	Water displacement.	sr
	Water displacement.	tr
Charlie	*Ok, so we use water displacement to find volume. What was the other method we used to find volume? Charlie?*	tr tq
	Find length, width and height and multiply them together.	sr
	Length times width times height.	tr
Kyly	*If you have measured the volume, what other piece of information are you going to need to find density? Kyly?*	tq
	Mass.	sr
	The mass.	tr

Sam	You want us to use that scale or that scale? (pointing)	sq
	You are just going to use the electronic balances. It has a built in scale so you can just use the electronic balance.	tr
Tammy	I have a question.	sr
	Yes?	tq
	For the second question, um, when you explain it can you use evidence from over here?	sq+ tr
	Yeah, you could. So when you found the volume of the same object, using the ruler, and you found the volume of the object using water displacement, what did you find the volume to be?	tq+ sr tq
	Equal.	sr
	Ok, they're equal?	
	Yeah.	tq
	So, it was 1 centimeter cubed when you measured with the ruler and 1 milliliter when you measured with the water. So, even though it was the same object you got 1 for the volume, right?	sr tr
	Yeah.	
	But one of the units were cubic centimeter and one of the units was milliliters, and we can say those are interchangeable, 'cus if you take the same object and you measure it, and you know, centimeters cubed, the volume and if you dropped it in the water, it would also have the same, it would be the same.	sr
	OK.	
Sam	*So what did you guys find when you measured the dimensions and measured with water displacement? What did you guys find?*	tq
	1 centimeter cubed.	sr
	1 centimeter cubed. What was the volume when you dropped it in water?	tr, tq
	It was 1 milliliter.	sr
	1 milliliter. So, the volume for both was 1. But they have different units.	tr+
	Yeah.	sr
	Okay… so when we measure, depending on what we measure, how we measure the volume, we get different units, but the number is the same.	tr
	Yeah.	sr
	So does it make sense then that we can use either milliliters or centimeters cubed to mean the same thing?	tq+
	Yeah.	sr
John	*Ok, so you have volume of cube is one, so they're the same. Ok, um, now we need to make sure this is…so grams per milliliter. What does this say?*	tr tq
	That's just a dash.	sr
	Ok.	tr
	That's supposed to be milliliter.	sr
	Ok, so just make sure you make this a complete sentence "…are another unit of density".	tr
	Ok.	sr
Sam	So, um if you were writing the density, would it be 1 gram per centimeter cubed?	sq

	Ok, so, how did you figure that out?	tq+
	Well, density is equal to mass divided by volume and the mass is 1 and the volume is also 1.	sr+
	Ok, so what was the unit of mass?	tq
	Uh.	sr(0)
	So it's a 1-1?	tq
	Uh.	sr(0)
	Mass, when you measured the mass on the balance, what were the units? You can look. It's on, so….	tq tr
	Oh…grams.	sr
	Grams. And you are divided by units of volume, so that would be…gram per, yep!	tr tr
Stephanie	Can we write these like this?	sq
	Uh, yes.	tr
Sam	Are we going to turn them in, or turn in everything?	sq
	We are going to turn these in.	tr
Robert	*Ok, so what is density?*	tq
	How thick it is.	sr
	What was it?	tq
	How thick it is.	sr
	Kinda, but you look at it by comparing um, your mass and your volume, okay, making a ratio of mass to volume. So you need to find the mass. Did you guys find the mass of your object?	tr tq
	It's 1 gram.	sr
	It's 1 gram?	tq
	Yeah.	sr
Sam	*Ok, Sam, can you help Robert find the mass of his object?*	tq
	Sure.	sr
Stacy	*Did you finish your prediction?*	tq sr(0)
	Oh…	
Mark	Which pages are due today?	sq
	2, 3, and 4.	tr

Table 3.3 - Feedback events transcribed and coded

Feedback factors. There are 6 feedback factors and explanations provided (*see Table 3.4*) in addition to a count of feedback conversations that is used to determine the rate of teacher feedback conversations as a quality of teacher practice.

Table 3.4 - Feedback factors and explanations

Feedback Factor	Explanation
Rate	This is a measure of how often feedback conversations occur during a lesson or the rate of conversations. A conversation is counted from the time it begins between teacher and a single student. For each student, data are kept on the total number of feedback events that they participated in.
Length	Feedback conversations are coded for length as measured in terms of total number of moves.
Initiator	Each feedback event is initiated by either the teacher or the student – the first move is either a more by student or teacher. Initiator is coded 0 for teacher and 1 for student.
Reasoning	This is a didactic measure of whether or not reasoning was applied by either the teacher or student during the feedback event. Reasoning is used as an identifier for constructivist thinking. Feedback events that include reasoning involve knowledge that is "constructed" which is different from feedback conversation that involve didactic, procedural or directive or repeated information. As soon as one of the turns of a feedback event for teacher or student contains reasoning, the entire event is considered a conversation with reasoning and receives a code of 1. Feedback events without reasoning receive a code of 0.
Balance/Question Response	Balance is an indicator of roles assumed by teacher and student during a feedback conversation. If a teacher asks as many questions as a student asks, then the event is well balanced in the area of questioning and is coded 0. If a teacher responds an equal number of times as the student, then this is also balanced for response. If a teacher only asks questions and the student only responds, then the result will yield a negative value for teacher role and a positive number for student role.
Critical Position	Position is an indicator of feedback being used for error detection. When a teacher expresses dissatisfaction in some aspect of a student's response, action, work or attitude this is coded "1" for position. The teacher has taken a position on student performance and communicated that he or she is dissatisfied. This is not an indicator of the correctness of student work or student thinking, but rather an indication that the teacher was critical of some aspect of the student's performance.

Coding for initiation. Each feedback event is initiated or prompted by either teacher or student. When students are initiating feedback, this is a measure of their interest level and belief in feedback as well as an indication of the degree of safety they feel in the classroom. Initiator becomes a proxy measure for classroom environment and how comfortable students are in beginning a communication with their teacher.

Coding for reasoning. When a teacher asks a student to respond to something that is new to the student, something they have not seen before or have not been told before how to do, it requires the student to use reasoning. This teacher move and student move is then coded for reasoning. When a student asks a teacher for some didactic piece of information, such as the date that an assignment is due, the teacher is not required to use reasoning when providing the answer; instead the teacher provides a factual response that can be repeated from memory or by referring to the class calendar. When there is nothing new being constructed between teacher and student, the feedback event is not coded for reasoning. For a feedback event to be coded for reasoning, no more than one move needs to be coded for reasoning. If a teacher asks a student a question that requires more than recall, but the student does not respond or there is no evidence that they are constructing a new understanding, the teacher question move is coded with reasoning, (tq+), the student response is not coded with reasoning, (sr), and yet the entire conversation is considered to include *Reasoning.* In other words, coding rules are that only the teacher or the student must demonstrate reasoned thinking and in just a single move for the entire feedback event to receive a score of "1" for *Reasoning.*

However, if a student asks a teacher for the due date of an assignment and the teacher responds in a way that prompts the student to remind the teacher of a field trip that day and from this an exploratory conversation arises in which the teacher and student apply reasoning in order to generate a new understanding — this feedback event will be coded for reasoning. This example is particularly significant because it demonstrates the coding rules and the coding of feedback extend beyond meaning related to lesson content. Teachers (and their students) apply reasoning throughout a lesson to many topics, including self-regulation and even social skills, and all types of reasoning are considered the same and included as part of a quality of the feedback conversation. The emphasis in this study is on whether or not reasoning happened during feedback conversations between teacher and student and not on why it happened or the meaning behind the reasoning.

Reasoning here has been defined as the process of arriving at a new solution, beyond what is factual or didactic information or information that has been said before. The number of turns in a feedback event may be a good indicator of reasoning. Reasoning requires a longer feedback event, so length of feedback may be an indicator of reasoning. And longer feedback events may indicate that a certain level of safety or comfort has been established between teacher and student and meeting this condition is required in order to inject reasoning into the conversation

Parameters for coding an interaction as containing reasoning were deliberately defined in what may seem like overly broad ways to capture every opportunity for teacher and students to co-construct meaning. The teachers who participated in this study work in an

environment where curricular goals are tightly regulated. Coding rules were designed to detect constructivist thinking of the smallest degree in district conditions where curricular and learning goals are tightly controlled by administrators, for even in this case, there exists opportunity for teachers and students to construct meaning together during feedback conversations.

In addition to the tight control of curriculum and classroom lesson plans, assessment is formally conducted in a single way by these participating teachers — by way of district-authored quizzes and tests made of multiple choice and short answer items. Even under these controlled assessment conditions, it is possible for students and teachers to apply reasoning to advance their understanding of how to do well on these assessments. Feedback conversations are the way that teachers and students reflect on metacognitive and other higher order thinking or self-regulated learning activities and talk about how to learn for success on these types of assessments vs. how to learn for the type of inquiry activities that are regularly practiced by scientists in the field. Under these strictly controlled assessment conditions, there is still room for students and teachers to talk about learning how to learn and to build new understanding that will be coded as reasoning in their feedback events.

Coding for question, response balance. Each feedback event produces 2 balance indicators: one addresses questions and the other targets responses. These factors are used to indicate who takes on the role of information-seeker and information-holder during a feedback event. To calculate question-and-response balance for the coded feedback event {tq, sr, sq, tq, sr} the number of teacher moves is simply subtracted from the number of student

moves. Question and response balance scores are then -1 and +2, respectively. Given another event, {tq, sr, sq, tr, sr, tr} the scores are balanced or are both 0, because the number of questions and responses are the same for teacher and for student. Thus feedback with greater balance is feedback in which the roles of seeker and holder of information are not assumed by teacher or student—which might indicate that the roles are shared. Because short feedback events (i.e., events of only one or two turns) will most likely be made of a question and a response, the roles of the teacher and student will be coded as opposite leaving the teacher and student in opposing roles.

Coding for teacher critical position. This factor identifies a feedback event in which the teacher takes the position of dissatisfaction with some aspect of a student's performance. Although expressing dissatisfaction does not sound, on the surface, like a very good thing for a teacher to be doing in feedback, expressing dissatisfaction is an example of feedback as error correction and as such, is considered a necessary component for meaningful critique. Position in this coding scheme is an indicator of power in feedback as feedback that provides students an opportunity to advance in their understanding or in their performance is powerful feedback. Position is an indication that the teacher has something better in mind for the student. There is a challenge involved. Everything is not roses. When a teacher expresses dissatisfaction during a feedback event, the teacher move is coded with the minus symbol "-" to communicate that the teacher expressed that the student's work, ideas or performance is not what the teacher is looking for. Although a minus sign, a "-" carries with it negative connotations, teachers can share dissatisfaction with a student and communicate that they care

about the quality of the work. Students who need feedback that helps them to know what they need to do to improve, should find their teachers express a negative position during feedback. A teacher who communicates to a student that they are not satisfied also communicates that they have higher expectations for the student, that they are paying attention, and that they care about the quality of a student's work or thinking.

Coding and Reliability

Although reliability takes a back seat to other interests in some educational research, it is a prerequisite for valid claims (e.g., Crooks, 1988; Broudy, 1988; Cole, 1986; DiSibio, 1982; Ebel, 1982; Glaser, 1985; Linn, 1983; Mesick, 1984a, 1984b; Quellmaltz, 1985; RothKopf, 1988; and Thorndike, 1969) and taken very seriously in the study design and methodology.

Coder training. In order to increase reliability to acceptable standards, two raters participated in three training sessions to learn to reliably apply coding rules to digital video recordings. Rater 1 is a Ph.D. candidate in Educational Psychology with 20 years of teaching experience. Rater 2 is a college-educated business owner and mother of two school-age children, but had no training in the field of education or learning science.

In session one, the raters sat together and observed sections of video without coding. They discussed what they noticed, shared their observations and talked about the challenges they encountered in identifying students. During this session, they created a student seating chart, identifying students and learning student names.

During session two, the two raters watched a portion of the same lesson, scored it independently, and compared results. When there was a disagreement in coding the two raters discussed the difference and came to an agreement. During this process, coding guidelines were re-written and clarified and inter-rater reliability improved. A persistent challenge remained in identifying students when they were involved in a feedback event, but not captured on camera. On occasion it was not possible for the raters to determine which student was involved in the event, resulting in a code of "ct" or "can't tell" for student identity. Feedback events were more likely to be scored "ct" if they were very short and involved little substance. Such feedback events were still coded and counted, but could not be attributed to any student with certainty. This meant that "ct" events were left out of student level analysis. Longer feedback events provided raters greater opportunity to identify students. Raters learned quickly that video recording quality was a deciding factor in the series of five lessons chosen to code. For high quality video recording, the camera followed feedback conversations between teacher and student, making it possible to quickly identify the student participant. Early on, raters learned to accurately identify students by name and voice, which improved the efficiency when coding future conversations within the same group of students.

A second challenge in coding for raters relates to audio limitations of the digital video recording. It happened on occasion that one of the raters would detect a move that the rater could not hear, such as a student quietly responding "okay" to a teacher's statement or question. When one rater did not hear a move, raters' codes differed by one move and the video clip was reviewed and discussed until raters identified the problem and reached

agreement. The discrepancy in raters' codes due to one rater missing a move resulted in a difference of 1 on length and a difference of +1 on *Response Balance*. *Reasoning, Position, Question Balance, and Initiator* remained unaffected.

The third and final training session included tests for inter-rater reliability, which required both raters to independently code the same portions of a lesson. Scores from this third session were compared. Inter-rater reliability was determined by counting the number of events for which there was complete agreement and dividing by the total number of events coded. The rate was determined to be greater than 89% and deemed acceptable for the purposes of this pilot study.

Comment on reliability and rater agreement. Before beginning the practice of coding feedback events, the two raters predicted that reasoning would be the most difficult thing to identify and agree upon in the coding process. Reasoning is identified in this study as a marker of constructivist teaching and learning in feedback. It was supposed that only seasoned educators had the expertise necessary to spot reasoning. When the second rater was included in the process to measure inter-rater reliability, learning type or the act of reasoning was introduced as "thinking evident in conversation that happens when something is new to the teacher or student beyond being told to do or think something in a new way. It is an open ended instruction where the answer is not just handed out. Student or teacher can ask a question or present information that leads the other person to apply reasoning". That introduction was a successful description of how to identify the act of reasoning. The second rater was not trained as an educator, although she is interested in concept in education and has

2 children attending public schools. It was interesting to see how quickly this second rater adopted a constructivist understanding and was able to identify reasoning. Inter-rater agreement in the coding of feedback events for reasoning was over 95%, an indication that understanding constructivist teaching is something parents outside who are not educators can do, such as this second rater, to benefit from understanding learning beyond rote memorization and didactic, teacher centered instruction. Within these sample data, feedback events were coded for reasoning only 19% of the time, and in the case of one teacher, the average percentage of reasoning was as low as 9%. Furthering research on teacher feedback using this methodology will allow for understanding, among other things, how inter-rater reliability changes when coding for reasoning in new learning environments with more or less of an emphasis on constructivist teaching.

Because of this observation, a further comment is needed on the way in which reliability between raters was reached and what that implies in this study as well as how what was learned might be applied to better understand inter-rater reliability in future studies that use this system or a similar system of coding. In the present study, inter-rater reliability was calculated between two raters who coded the same feedback event. Agreement was met between raters if only they were in 100% agreement on each move. In this way, no partial credit was awarded, such that if one rater arrived at the sequence {tq, sr, sq, tr, tr, sq, tr) and the second rater arrived at the sequence {tq, sr, sq, tr, sq, tr} agreement was not met. But if the two example codes are examined more closely, in the light of the 6 pieces of evidence that will be extracted from the codes, the two raters did reach 100% in 4 of the 6 factors. They

agree upon *Initiator, Learning Type, Question Balance and Position*. They do not agree on *Length* and *Response Balance.* And in terms of their disagreement on *Length* and *Response Balance,* the two codes are only off by 1 count. It was shown in Chapter 3 that the coding rules for this study produced a very high rate of reliability, and yet a further look can be made to understand inter-rater reliability by factor and to discover which of the 6 factors are considered the most stable.

Data Organization

In the spreadsheet used for data analyses (*see Figure 3.2)* each row represents one feedback conversations and coding for each move in the conversation. This format was used to calculate the overall average scores for each of the 6 variables, *Initiator, Learning Type or Reasoning, Length, Response Balance, Question Balance and Position*. Every feedback event is identified by teacher and student involvement as well as by student score, which is a format that is used to answer questions regarding student experience in feedback events and teacher involvement in that experience.

	A	B	C	D	E	F	G	H	I	J	K
1	teacher_ID	lesson_ID	student_ID	score	feedback event	initiator	learning type	length	response	question	position
2	1	2	122	100	sq, tr	1	0	2	-1	1	0
3	1	2	120	89	sr, tq, sr	1	0	3	2	-1	0
4	1	2	115	95	sr, tr	1	0	2	0	0	0
5	1	2	123	83	sq, tr	1	0	2	-1	1	0
6	1	2	113	88	tq, sr	0	0	2	1	-1	0
7	1	2	112	63	(-)tr, tq, sr	0	0	3	0	-1	1
8	1	2	106	98	tq, sr	0	0	2	1	-1	0
9	1	2	103	88	tr	0	0	1	-1	0	0
10	1	2	108	93	tq, sr	0	0	2	1	-1	0
11	1	2	102	78	sq,tr	1	0	2	-1	1	0
12	1	2	112	63	tr	0	0	1	-1	0	0
13	1	2	120	89	sr	1	0	1	1	0	0
14	1	2	121	78	sq	1	0	1	0	1	0
15	1	2	114	69	tr	0	0	1	-1	0	0
16	1	2	115	95	tq,sr,tr	0	0	3	0	-1	0
17	1	2	110	89	sq,tr	1	0	2	-1	1	0
18	1	2	124	74	sq,tr	1	0	2	-1	1	0
19	1	2	117	95	tq+, sr+, tq+, sr+	0	1	4	2	-2	0
20	1	2	106	98	tq+, sr+	0	1	2	1	-1	0
21	1	2	120	89	tq+, sr	0	1	2	1	-1	0
22	1	2	123	83	sr+	1	1	1	1	0	0
23	1	2	111	79	sr+, tr+	1	1	2	0	0	0
24	1	2	105	72	sr+, tq+, sr+, tr+, sr+, tr+	1	1	6	1	-1	0
25	1	2	104	85	sr+	1	1	1	1	0	0
26	1	2	124	74	sr+	1	1	1	1	0	0
27	1	2	122	100	sr+, tr+, sr+	1	1	3	1	0	0

Figure 3.2- Spreadsheet used in analysis

Count Data

By coding each conversation for *Initiator, Length, Reasoning, Response Balance, Question Balance and Position* the likelihood each one occurred can be determined. This was done by writing macros in the Excel spreadsheet. Of these 6 values, coding for *Initiator, Reasoning and Position* resulted in binary outcomes or whether these things happened or not during a feedback conversation. For *Initiator*, "1" indicates that the student invited the teacher to engage in the feedback event. For the factor *Reasoning*, "1" indicates that new thinking was addressed in the feedback event. In the case of *Position*, "1" indicates that the teacher communicated dissatisfaction to the student during the feedback event. In the case of *Length,*

interval values that indicate how long a feedback event lasted (in moves) were transposed into levels *(see Table* 3.5) and treated as ordinal data that can be counted.

Length Value	*Level*
1 move	1
2 moves	2
3 - 5 moves	3
6 - 14 moves	4
more than 14 moves	5

Table 3.5 – Length as ordinal data

To calculate *Question*, number of teacher moves as questions is subtracted from number of student moves as questions for students to indicate whether teacher or students took on the role of information-seeker. The same was done for *Response Balance* in order to determine if teacher of student played the role as information holder. In both cases, if neither teacher nor student assumed the role, the result would be 0. That difference is easily transposed to indicate role (*see Table 3.6).*

Raw score	*Transposed to ordinal value*	*Role assumed by*
lowest value to -1	0	teacher
0	1	balanced
1 to highest value	2	Student

Table 3.6 - Transposing balance into ordinal data

Analysis of Count Data. One objective for this study is to understand teacher effect on the experiences of students as identified by their score level in the class. To do this, log-linear analysis is used and contingency tables are tested for significance. Log-linear analysis is a type of chi-square test in which the values are calculated using weighted natural

logarithms. There are two advantages of the log-linear method and they are that the chi-square values that are calculated are linear and this means that more complex analyses are allowed beyond what is available in the usual chi-square analysis and secondly, 2 and 3-way contingency tables can be calculated easily by simply adding and subtracting different combinations of weighted algorithms.

For the third part of this analysis that seeks to understand teacher effect such as teacher interaction on student score and reasoning, 3-way contingency tables are populated and log-linear analysis is used to test for teacher effect. For the inquiry that involves 3 variables, cross-tabulation tables were calculated and the frequencies analyzed using log linear analyses in order to control for the effects of a single factor, *teacher*, while investigating the relationship between other factors as well as any earlier discovered 2-way interactions. The log likelihood ratio, or G^2 test, which is distributed approximately as chi-square and defined by the degrees of freedom, will be conducted and the Gamma coefficient will be used to measure the strength of a relationship, which is appropriate for factors placed in ordinal categories.

Considering Student Score

Student score transformed into ordinal data. In this study, student score is considered a measure of achievement in science class as well as an indicator of self-efficacy or student sense of self-worth as a science learner. Student score for this study is the average of the first three quarter grades in science for that school year. Data from the feedback events of students who did not consent to share their science grade were treated as missing data.

For analysis, student score was transformed from scalar to ordinal. Four levels were identified and labeled 0 thru 3, with 3 as students with the highest science score in the class. At the feedback event level, occurrences of a particular variable relative to the total number of conversations for that student will be analyzed.

Capturing student data and accounting for missing data. This dissertation is an exercise in presenting a reliable and feasible method for measuring feedback practices in teachers and capturing what can be learned from employing the measurement process. Because one explicit goal of this dissertation is to provide reliable information that can be used by teachers, it follows that the method being described in this study must explain the experiences of students with teacher feedback and how student scores are related to feedback conversations they have with their teacher.

One general hypothesis is that high achievers experience certain types of teacher feedback or certain qualities of teacher feedback that are not experienced by students who struggle in science and who have low science scores. If it is the case that all students, regardless of their score in science, experience the same qualities of feedback conversations with their teachers, it can be claimed that all students are challenged in the same way to utilize the feedback they are given from their teacher. Consider, for a moment, the feedback factor *Position:* although position, which signifies teacher dissatisfaction, does not sound like a good thing, it symbolizes good things – the teacher's commitment to feedback as a constructivist opportunity that leads to new student thinking or behavior. *Position* has been identified in feedback research as a necessary activity of teachers who are using feedback as error

detection. If teacher does not take a position on student work or thinking, then the student is on his or her own or if teacher takes position for only students with certain class scores, this indicates that only certain students are experiencing challenge within in their science studies or that the teacher has singled out a certain group to critique. It seems reasonable that having equitable access to meaningful critique might impact student science scores across the class.

In addition to analysis of interactions between student score and feedback factors, analysis will be conducted to test for teacher effect. It may be that an interaction exists between students with certain science scores and the feedback conversation they experience or that the interaction exists only in the case of certain teachers. An interaction, moderated by the teacher, is evidence that teachers build unique feedback practices and demonstrate their understandings of the purpose of their conversations in different ways. This finding documents the power that teachers have in their assessment practices that are exercised in unique ways.

Chapter 4: Results

Overview

This dissertation study seeks to demonstrate a reliable and feasible method for understanding the feedback practice of teachers during classroom lessons and communicate findings as information for teachers to use to improve their individual feedback practice. This research measures the rate of which certain qualities are demonstrated within feedback conversations between teacher and student and captures the distribution of these qualities to students so to understand if feedback conversations, by quality and quantity, are related to student self-worth indicated by their overall scores in the class.

The educational literature does not agree on a single way in which to explain the effects of feedback practice and what exactly should be the focus when understanding teacher feedback. Studies have presented the power of feedback in terms of timeliness (Kulhavy & Anderson, 1972; Kulik & Kulik, 1988), type of information (Hattie & Timperley, 2007), error detection (Yeany & Miller, 1983; Bangert-Drowns et al., 1991) and motivation (Butler & Winne, 1995, 1987; Mory, 2004), with learning happening within the interaction between teacher and student (Chin, 2006; Oldfather & Dahl, 1994). This study intends to demonstrate a much needed method for feasibly capturing reliable information about the generic habits of teachers or feedback habits of teachers during conversations with their students.

For this study, the feedback practice of a teacher is comprised of all the individual conversations a teacher conducts with their students during classroom instruction. And each of these conversations can be coded in six ways by certain qualities to represent the nature of

those conversations. Understanding the feedback practice of teachers in terms of the prevalence or likelihood of certain things during independent feedback conversations paints the picture of the practice of that teacher as well as the experiences of students within that practice as these relate to the self-worth of a student of science. For review, the six qualities are *length* or number of moves, *initiator* or who begins the feedback conversation, *reasoning* or the presence of new or constructed information, *response balance* or who plays the role of information holder, *question balance* or who plays the role of information seeker, and, finally, *critical position* or whether teacher expresses any type of critique or dissatisfaction to the student during the exchange. When feedback conversations are coded over time, the presence of these factors indicates more than teacher feedback practice, but classroom environment, reasoning or constructivist teaching, role playing and error detection. In addition, the quantity of feedback that individual students experience indicates a teacher's belief in their capacity to engage students and impact learning at all levels. How feedback conversations are distributed over students is an indication of teaching equity for students during the learning process. Because this dissertation study is interested in how students experience feedback, it requires both measures of quantity and quality to understand the feedback practice of a teacher and capture the feedback experiences of students within a practice.

This chapter has three main analytical sections based upon analysis of data at the feedback conversation level. The explanations of these sections and ensuing analyses are summarized in Table 4.1.

Table 4.1 – Overview of Analysis

SECTION	*HYPOTHESES*	*PROCESS*
I Relations between feedback factors	Hypotheses about relationships between feedback factors are presented. Correlations are examined and used to build a validity rationale for accepting factors and understanding the relationships between factors, and considering the possibility that factors might be collapsed because they do not contribute uniquely to the construct of teacher feedback.	Cross tabulations are calculated using Chi-square tests and, if significant, the p value for model fit ($p<.05$ implies that the model fits better than chance) and the Gamma statistic for strength of association or variance explained by the model are reported.
II Interactions of feedback factors with student self-worth	Hypotheses about relationships between student score as an indicator of student sense of self-worth and feedback factors are presented. The general hypothesis is that student self-worth is related to the feedback conversations they experience in terms of *quantity, roles, initiation, length, reasoning,* and *position*.	Cross tabulations are calculated to determine if a significant relationship exists between student score level and feedback variable. Chi-square and Gamma statistics will be reported in the case of significance.
III Test of teacher effect	Contingent upon the findings in Section II, a three-way interaction is used to understand if there exists a teacher effect or if the interaction detected in Section II is stable across teachers. It is suspected that student experience as measured by the feedback factor, *reasoning,* does significantly relate to their self-worth as score in the class, but only in the case of certain teachers. In other classrooms, teachers are mitigating this effect.	Cross tabulations will be detected for all 2 way interactions between student score, *reasoning* factor, and teacher. From these cross tabs, log-linear analysis will be applied in order to control for the factor and understand if the factor contributes significant information to the model. Chi-square and Gamma statistics will be reported in the case of significance.

Section I - Understanding Relationships of Feedback Qualities

Hypotheses and findings

Hypothesis 1. It is hypothesized that longer feedback conversations are more likely to involve reasoning, an indication that thinking is being constructed, new ideas or information are being shared. Coding rules for *reasoning* in feedback conversations does not distinguish between who is doing the reasoning, teacher or student. And as soon as a single move involves *reasoning*, the entire conversation is coded positively for the activity.

To understand the relationship between *length* of conversation and *reasoning*, the following categories were established for length and ordinal categories identified: 0 or 1 move, 2 moves, 3 - 5 moves, 6 - 14 moves, more than 14 moves.

From the data of 2021 successive feedback conversations, l*ength* tended to be short. Feedback conversations involving two or fewer moves accounted for 50% of all feedback events. Conversations with 3-5 moves accounted for 36% of all conversations and conversations with 6 or more moves made up the remaining 13% of all conversations. It was found that a significant relationship exists between *length* and whether the conversation involved *reasoning*, with $\chi^2(4, N = 2021)= 322.00$, $p < 0.001$, $\gamma = 0.70$. The relationship between *length* and *reasoning* is illustrated in *Figure 4.1*.

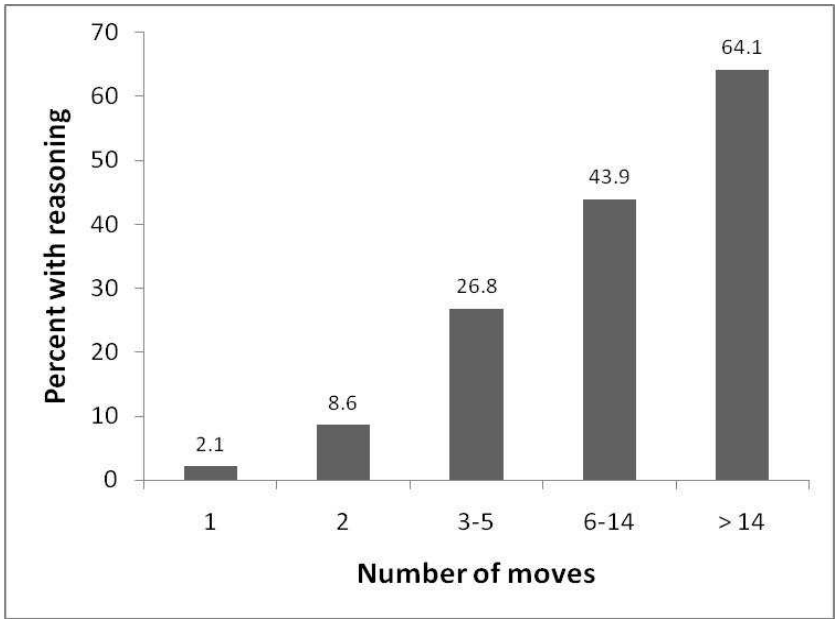

Figure 4.1 - Percent of feedback conversations with reasoning for conversations having varying number of moves.

Hypothesis 2. The teacher plays the role of information seeker most often in feedback conversations. Roles as information holder and information seeker are distinct within feedback conversations. This analysis seeks to know the relationship between the roles of teacher and student as information seeker or holder. For instance, if the teacher is the main questioner during a feedback conversation, does that ensure that the student will assume the role of information holder? And how likely is it that this will happen?

In 43% of feedback events the teacher played the role of information seeker and asked most of the questions. In 38% of the events the teacher and student asked the same number of questions and in only 19% of the feedback events the student acted as the primary questioner.

These teachers tend to assume the role of questioner during feedback conversations with their students.

Next, a closer look at the relationship between the roles of information seeker and information holder is investigated. A significant inverse relationship exists between these variables with $\chi^2(4, N = 2021)= 972.88$, $p < 0.000$, $\gamma = -0.845$. The data show (*See Table 4.2)* that when the student assumed the role of questioner, it was quite unlikely that they would answer their own questions, or assume the role of the information holder (1.3%). This very small percentage indicates that the roles of information holder and seeker are separate and can be accurately identified. It was learned that the teacher mainly played the role of questioner during feedback conversations (87%). In addition, few feedback conversations were coded with teacher as both information seeker and holder (5.1%) or with student as both information seeker and holder (1.3%). Information seeker and holder are roles that teacher and student take on uniquely and distinctly during their shared feedback conversations.

In addition, when the teacher took the role of information seeker and asked the majority of the questions, they often shared the role of information holder with the student, (53%), or the student held the role of information holder (42%). The shared role of information holder during feedback conversations with teacher as the main questioner indicates collaboration between teacher and student in contributing information to resolve the questions the teacher posed. When teachers take on the role of information seeker, it is more probable that they will share the role of information holder with their student over allowing

the student to be solely the information holder, providing responses and expert knowledge on their own

Table 4.2 – Question Balance by Response Balance (percentages are within rows)

	Response Balance		
Question Balance	Predominantly Teacher	No Difference	Predominantly Student
Predominantly Teacher	5.10 (44)	52.90 (461)	42.00 (366)
No Difference	61.70 (475)	29.90 (230)	8.40 (65)
Predominantly Student	86.60 (329)	12.10 (46)	1.30 (5)

And of greater interest, when the student took on the role of questioner during feedback conversations, it was most common (87%) that the teacher held the role of information holder and provided the student answers to these questions and did not answer questions with questions. When students took on the role of question seeker, the teacher's role was quite distinct as information provider or holder.

It was learned during this analysis that in only 12% of those conversations where the student asked most of the question, the teacher and student shared the role of information holder, and provided the same number of responses. These findings seem to show that when the student takes on the role of information seeker, and drives the feedback conversations by asking most of the questions, the teacher is much more likely to assume the role of

information holder, providing information to the student, and far less likely to share the role of information holder with the student. From this, it is suggested that teachers view student questions as a responsibility that they satisfy with direct responses and not with further questions. If the student asks the majority of questions during a feedback conversation, the teacher responds with information they appear to require. Findings that would more closely align with constructivist learning in feedback conversations would find the role of information holder shared between teacher and student when the student drives the event with their questions.

Hypothesis 3. If feedback is coded for *position*, meaning that the teacher took a critical position or expressed dissatisfaction to the student, it is most likely initiated by teacher. When the teacher identifies an error in student work, thinking or behavior and communicates this critique, the feedback conversation is coded positively for teacher *position*. In order to provide information that students need to improve, the teacher must identify something dissatisfying and share some sort of disappointment. This sharing of disappointment can be as subtle as telling the student that their thinking is not fully formed or that there is more they need to consider or that the student's thinking is not accurate. To be coded for *position*, the teacher must let the student know that something is not as it should be. This hypothesis relates to how likely it is that teachers will initiate a feedback conversation and express a critical *position* related to any aspect of student work, thinking or behavior.

As shown in Table 4.3, teachers initiate 60% of all feedback conversations and they assumed a critical position in only 6.5% of all feedback conversations. They were four times

more likely to bring up critical issues when they had initiated the conversation (9.5%, n = 115) than when the student initiated the conversation (n = 17). This difference was statistically significant with $\chi^2(1, N = 2021) = 42.44$, $p < 0.001$, $\gamma = -0.661$.

Table 4.3 - Initiator by Teacher Critical Position (percentages are in rows)

	Teacher Critical Position		Total
Initiator	With	Without	
Teacher	9.50 (115)	90.50 (1095)	60.00 (1210)
Student	2.10 (17)	97.90 (794)	40.00 (811)
Total	6.50 (132)	93.50 (1889)	100.00 (2011)

Hypothesis 4. In feedback conversations that do involve reasoning, the teacher will most likely serve in the role of information seeker, asking most of the questions.

It was determined that only 19% of all feedback events were coded for reasoning. Of that percentage of feedback conversations, the teacher assumed the role of information seeker 77% of the time and students played the role 10.2% of the time. A significant inverse relationship was detected between reasoning being present in feedback conversations and student in the role of information seeker, $\chi^2(2, N = 2021) = 224.30$, $\gamma = -0.614$, $p < 0.001$. In addition, only 12.8 % of feedback events that involve reasoning were balanced meaning that when reasoning happens during feedback conversations teacher and student are rarely

involved to the same degree in asking questions, that is, that one player is assuming the role of questioner or information seeker.

Table 4.4 – Reasoning Involved by Role of Questioner (percentages are in rows)

	Question Balance		
Reasoning Involved	Predominantly Teacher	No Difference	Predominantly Student
With	77.00 (295)	12.80 (49)	10.20 (39)
Without	35.20 (576)	44.00 (721)	20.80 (341)

Hypothesis 5. When a feedback event involves reasoning, teachers will also likely take a critical position, pointing out problematic thinking or communicating some sort of dissatisfaction.

The difference between reasoning that occurs with and without the teacher taking a critical position was found to be statistically significant, $\chi^2(1, N = 2021) = 4.29$, $\gamma = -0.272$, $p < 0.016$. The probability that reasoning and critical position occurred within the same feedback event is extremely unlikely. In fact, out of the 2021 feedback conversations coded, *reasoning* and *position* occurred in the same event only 16 times (*see Table 4.5*). When the teacher took a critical *position*, *reasoning* occurred in 12% of those conversations. And when no position was taken by the teaching, reasoning was somewhat more probable at 19% of the time. Reasoning was less likely to occur when a critical issue was addressed by the teacher (*refer to Table 4.5*). It is worth noting the significance of finding any relationship at all between these two conversational qualities, *reasoning* and *position* because they are so very

rare in these teachers' repertoires. And yet, a constructivist feedback event, with the type of shared understanding created, it would be expected that teachers would share dissatisfaction with students, even if the dissatisfaction was a reaction to misunderstanding or the incomplete student understanding during the construction of new knowledge.

Table 4.5 - Teacher's Critical Position and Reasoning Involved

	Reasoning Involved	
Teacher's Critical Position	With	Without
With	12.10 (16)	87.90 (116)
Without	19.40 (367)	80.60 (1522)

Although the relationships between reasoning and position is negative and not particularly strong, $\gamma = -0.272$, the rarity of each in these classrooms begs the wonder of how these factors would relate in the practices of teachers who incorporate more reasoning into their feedback conversations with students. If reasoning were a much more likely occurrence during feedback conversations, would position be more strongly and positively correlated? For in the feedback practices of teachers who regularly involve reasoning, critical position may be a more natural and expected activity for teachers in expressing their dissatisfaction as a method for leveraging deeper student understanding in the process of building a new, shared meaning.

Section I - Discussion of Findings

Results from section one found that feedback conversations tend to be short and that half involved only one or two moves. In addition, the longer the feedback event, the more

likely it is to involve reasoning. Within a feedback event, teacher is more likely than student to assume the primary role of questioner and in this case, the roles of question seeker and information holder identified as opposing and distinct roles. Teachers initiate most of the feedback events (60%) and rarely take a critical position or express dissatisfaction. Feedback events in which teachers take on a critical position are more likely to have been initiated by the teacher. Only 19% of all feedback events involve reasoning, but when this happens, it is most likely that the teacher plays the role of the primary questioner (77%). And when the teacher takes a position during feedback conversations, and expresses dissatisfaction for any reason to the student, the likelihood that reasoning will happen in that conversation is uncommon at only 12%.

It was also noted that teachers are driving the reasoning experiences in conversations for their students, and yet their conversations are carefully crafted and tactful, for they rarely express a critical position. It is possible that teacher expressions of dissatisfaction are used in a way that is unrelated to reasoning and does not encourage the construction of knowledge. It is suspected that teachers are using their position as a type of management tool and not as a way to leverage constructivist thinking and new understandings.

From this study, it can be assumed that feedback conversations that involve the construction of knowledge as evidenced by the presence of *reasoning* are rare. In addition, the longer the feedback conversation, the more likely that *reasoning* is to happen. Reasoning, from either the teacher or student during feedback conversations, requires taking a risk, particularly during classroom lessons where the activity is not common or considered counter

culture to normal activity of didactic exchanges, directives or commands or the sharing again of information that has already been shared. Reasoning, as an indicator of constructivist thinking, is not a simple activity for it is often based on the unexpected and not typically received. In many classrooms feedback conversations are used to deliver information, for recall or for repetition of what has been said before, in the past.

Reasoned thinking is often nuanced thinking that cannot be simply and easily communicated. To reason during a feedback conversation with another person requires a level of trust. When teacher and student have established the condition of trust in their relationship, it is supposed that they will be more comfortable with lengthy conversations and with the risk of exposing their ideas to the other. It may also be that longer conversations are needed for trust to be established and so it is conversation length that allows teacher and student to relax and share deeper understandings, ideas, questions or interests regarding what hasn't been decided in the past, ideas that are emerging, which may or may not be accepted because they may or may not belong. What comes first, a lengthy feedback conversation or a level of trust that allows for reasoning to happen cannot be understood from this study. That is for a future study, however when teacher and student engage in conversations of greater length, reasoning is more likely to emerge.

The role of information seeker was found to be primarily held by teachers during feedback conversations. However, teachers do create conditions that allow their students to ask the questions and this is done for all students, regardless of level of student self-worth. Students, regardless of level of self-worth as a science learner, take on roles of information

holder and seeker. It was found that teachers adopt different roles during feedback conversations and when they are primarily asking the questions, the student responds with the information that perpetuates their teacher's position as main stimuli producer, eliciting student engagement by asking questions. When the student assumes the role of information holder during the feedback conversation, the teacher is most probably asking the questions and has assumed the role of information seeker. This suggests that students rely on teachers to ask questions in order to share information. In this sample, only 19% of all feedback events were coded for reasoning. Of those feedback events, the teacher assumed the role of information seeker 77% while student assumed the role only 10.2% of the time $\gamma(2021) = -0.614$, $p < 0.001$. In addition, only 12.8 % of feedback events that involve reasoning are balanced, such that teachers and student ask the same number of questions and neither one assumes the role of questioner or information seeker.

What is of interest is the relationship between feedback events that are question balanced and that contain reasoning. When feedback events are balanced for questioning, meaning that neither the teacher nor the student assumed the primary role of information seeker, the event rarely contained reasoning (6.4%). This finding suggests that when the role of information seeker is assumed, a higher level of inquiry is generated, as measured by the presence of reasoning.

When feedback conversations are question driven by teacher, reasoning is more common than when students take the role and ask the questions. Teachers are not only more likely to play the role of information seeker, but they use the role to advance reasoning and

infuse reasoning into conversations with their students. This demonstrates that teachers know how to craft feedback conversations that involve commitment to deeper, constructivist learning conditions by asking the right questions and creating conditions that support reasoning. In addition, this may show that when students assume the role of question seeker within feedback conversations, asking more questions than their teacher, reasoning rarely happens. Students do not demonstrate reasoning to be something they are comfortable with and expected to do. Reasoning, an indication of learning construction, involves new thinking, more than what can be memorized or is procedural. Reasoning did not happen when students assumed the role of questioner during feedback conversations. Under this condition, student questions were limited seeking information of a didactic nature that had been shared before.

How often a teacher shares the role of information seeker with students, across feedback conversations, indicates capacity and willingness to share power and can be considered a quality of a feedback practice. Teachers share power by allowing students to drive conversations with questions. In the other case, they share power by allowing students to be the holder of information and to know the answer to their questions. Future research will show if this greater willingness on the part of the teacher to allow students to drive feedback conversations results in less feedback. For teachers may be driving feedback conversations with their students, asking more questions than their students, because they feel they must - without this, students would not be engaged in learning.

Section II - Feedback Conversations in Relation to Student Self-Worth

Student self-worth as indicated by scores. A focal point of this dissertation study is in understanding if student self-worth as a science learner is related to the feedback conversations that they experience with their teacher as coded by quantity and by factors *Initiation, Reasoning, Length, Response Balance, Question Balance and Position.* Overall score in the class is an indicator of more than student achievement, but, rather, it is considered a measure of student sense of self-worth as a contributing learner in the class. The four participating teachers in this study do not write their own lessons or assessments, but instead administer prewritten districts assessments. Because of this, a student's score in science is a reliable measure across classes, although it is not necessarily a valid measure of science knowledge. Student score in science is a score well known by each student, updated daily and posted in each classroom by the teacher and easily accessed via the internet from home. It is a score that is well known by the teacher for the teacher assigned the score. For this dissertation, overall science score is an indication of how well a student desires to and has the skills necessary to do well on written assessments in this class. This assessment measure, *score*, is an overall outcome measure and is an indicator of how a student feels about his/her capacity to do well in the class, an indicator of their sense of self-worth as a science learner.

The average grade in each of the four science classes is represented (*see Figure 4.2)* and the standard error of the distribution. It is visually clear that these four science classes are comprised of students who average the same level of achievement or sense of self-worth.

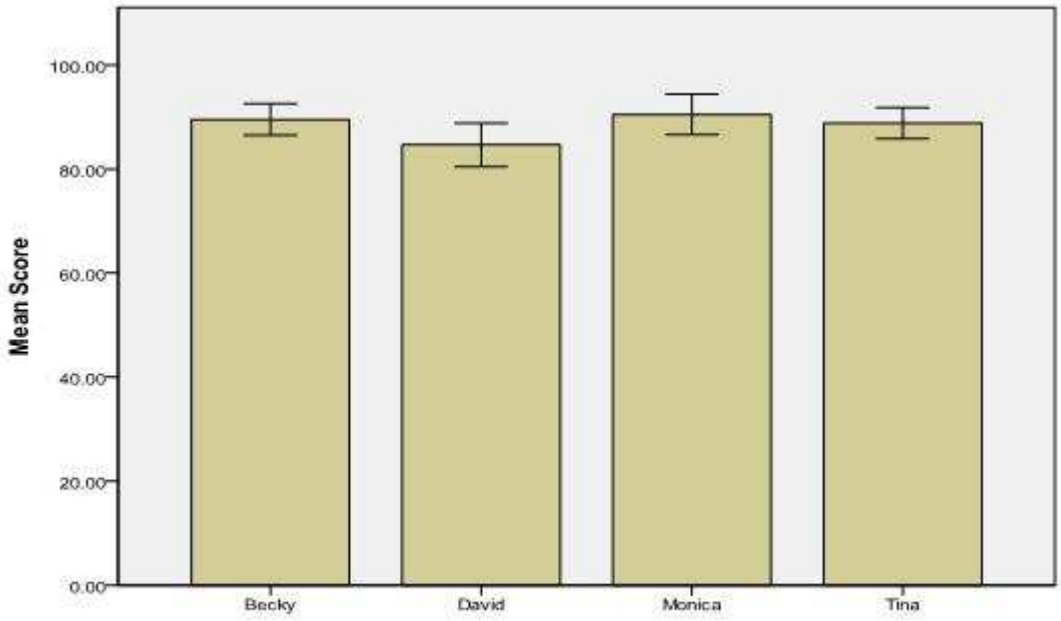

Figure 4.2 – Mean student grade in science and the standard error of the mean.

Average scores within the classes are similar, with David's class receiving the lowest mean score, 84.67. David's class is the only 6th grade class that participated in the study. They appear to have the lowest average sense of self-worth as compared to the other older students. From this, it is assumed that younger middle school students on average have a slightly lower sense of self-worth as science learners than their older counterparts.

Table 4.6 Student score in science

Teacher	*N*	*Mean*	*Std. Deviation*
David	25	84.67	10.49
Becky	24	89.54	7.40
Tina	24	88.85	7.26
Monica	20	90.50	8.78

A one-way ANOVA showed no significant difference in mean student score in science for the four participating classes of students (*see Table 4.7).* In addition, Levene's test for homogeneity of variance revealed no significant difference in variance. Since there was no significant difference in means and variance for the four classes, these groupings of students may be regarded as samples from a common population and not distinguishable by level of self-worth as science learners. In other words, the level of student self-worth is comparable across the four classrooms and no class of students is identifiable from another by sense of self-worth.

Table 4.7 - ANOVA Student Score by Teacher

	Sum of Squares	df	Mean Square	F	Sig.
Between teachers	470.562	3	156.854	2.123	0.103
Within teachers	6575.087	89	73.877		

Analysis of student experience with feedback. The emphasis in this next section is on teacher feedback conversations and student experience in relation to the level of self-worth they are experiencing in science. Do students who have similar scores in science experience

the same quantity and quality of teacher feedback conversations? Teacher feedback, unlike lesson plans and assessments are not composed or guided by administrators at the district level. They are, instead, a series of on-the-fly instructional and conversational decisions made by teachers who have developed a practice of stimulation in their classroom and, for all intents and purposes, are independent in this practice of stimulation and of feedback delivery. Teacher feedback signifies what a teacher believes students need at varying levels of self-worth.

Hypotheses and findings. For Section II, here starts the inquiry regarding how different students experience teacher feedback. Students in the same classroom have different feedback conversations and from this build their personal library of unique experiences that when taken together, with their peers, comprise the teacher's feedback practice. Understanding that teacher feedback is a powerful force in learning (Hattie & Timperley, 2007; Mory, 2004; Wiliam, 2011) the question becomes, "Are the different feedback conversations or experiences that students have in communication with their teacher related to their sense of self-worth?"

Hypothesis 1. The number of feedback conversations students have relates to student self-worth.

Student absences were adjusted by averaging feedback factor counts over the number of lessons attended. Chi-square test of cross tabulations revealed *no significant relationship* between student score and the number of feedback conversations students experience in the

feedback practice of their teacher. Teachers engage with their students in the same number of feedback events, regardless of student sense of self-worth or score (*see Table 4.9).*

Table 4.9 - Number of Feedback Events Experienced by Students by Score Level

	Number of feedback events		
Score Level	Low	Medium	High
1	35.00 (7)	25.00 (5)	40.00 (8)
2	33.30 (8)	37.50 (9)	29.20 (7)
3	36.00 (9)	40.00 (10)	24.00 (6)
4	37.50 (9)	41.70 (10)	20.80 (5)

Hypothesis 2. *Length* of feedback event is related to student self-worth.

Conducted just as in *Test 1*, Chi-square revealed no significant difference between students' self-worth and the length of feedback conversations they engage in with their teachers. Teachers generally engage in the same number of feedback events with students that last for generally the same length as measured in moves, and these factors are unrelated to student sense of self-worth or score in science class (A table was not included for this test.)

Hypothesis 3. During a feedback conversation, the likelihood that students will experience *reasoning* is related to their score level, such that high scorers are more likely to

engage in teacher feedback conversations that involved constructed knowledge or new information.

Because not all students consented to share their score in science, the number of feedback events included in these analyses was reduced to 1665. Results from crosstabs tests indicate that a significant relationship exists between student score and the likelihood that they experience *Reasoning* in feedback conversations with χ^2 (3, N = 1665) = 17.61, p < 0.001, $\gamma = 0.155$. Here it is shown by Gamma that a relationship exists, however it is not strong.

Table 4.10 - Reasoning Experienced by Students According to Score Level

	Reasoning Involved	
Score Level	With	Without
1	11.40 (42)	88.60 (326)
2	21.00 (82)	79.00 (309)
3	18.70 (79)	81.30 (344)
4	21.90 (106)	78.10 (377)

The graph (*see Figure 4.3)* clearly shows where the significant difference lies. Students were placed in one of 4 groups according to self-worth or score in the class. Students in the top 3 groups experience the same likelihood of *reasoning* in feedback conversations,

however this was found to be twice the rate of *reasoning* experienced by students who had the lowest self-worth.

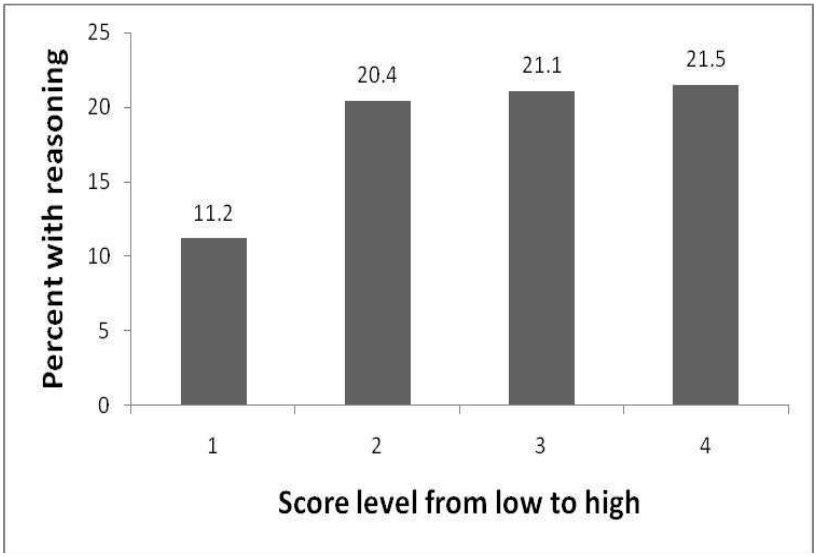

Figure 4.3 - Reasoning by score level in percentage

The experience of reasoning within teacher-student conversations and the evidence that learning is being constructed is not equally distributed across all students. Students with the lowest sense of self-worth participate in half the number of conversations that involve deeper thinking than higher scoring peers, higher self-worth peers – even though the number of feedback conversations is the same for students regardless of student score. Student score has been used as an indicator of how a student feels about himself or herself as a successful learner. Students who have the lowest scores in the class, and by association, the lowest levels of learner self-worth are experiencing and are exposed to far less teacher feedback that involves reasoning. It is suggested that classroom climate and conditions that support more

opportunity for longer feedback conversations will foster more reasoning and improve student self-worth, particularly for the lowest achievers. The feedback practices analyzed show that reasoning does exist in teacher feedback conversations, so it may be a matter of identifying when and where they take place in an effort to foster more and distribute deep thinking feedback to all learners.

Hypothesis 4. The rate that students initiate feedback conversations relates to self-worth. Again, crosstab cell counts are established and analyzed for significance (*see Table 4.11 below).*

Table 4.11 - Percentage Score Level by Initiator

	Initiator	
Score Level	Teacher	Student
1	67.7 (249)	32.30 (119)
2	64.2 (251)	35.80 (140)
3	58.2 (246)	41.80 (177)
4	54.2 (262)	45.80 (221)

It was determined that a significant relationship exists between student score and initiation of feedback with χ^2 (3, N = 1665) = 19.02, $p < 0.001$, $\gamma = 0.162$. Students with higher level of self-worth more frequently initiated feedback conversations with their students than their peers with lower self-worth.

Hypothesis 5. Teachers take a critical position or express dissatisfaction in feedback conversations relative to student self-worth.

Cross tabulations show that significant inverse relationship exists between student self-worth in science class and the likelihood that teacher will take a critical position during a feedback conversation with χ^2 (3, N = 1665) = 24.84, $p < 0.001$, $\gamma = -0.307$ *(Table 4.12)*. This finding suggests that students with the lowest sense of self-worth are most likely during feedback conversations to experience teacher critical position. This finding is significant. It suggests that students with low self-worth experience a higher percentage of teacher dissatisfaction and a lower percentage of reasoning, and that teachers are not expressing their dissatisfaction in ways that related to constructivist activity or reasoning. From these findings, it appears that teachers are taking a critical position with low scoring students for management purposes and not to introduce constructivist reasoning through conversations that lead to new understandings.

Table 4.12 - Teacher's Critical Position by Student Score Level (by percentage)

	Teacher's Critical Position	
Score Level	With	Without
1	13.00 (48)	87.00 (320)
2	6.60 (26)	93.40 (365)
3	6.40 (27)	93.60 (396)
4	4.30 (21)	95.70 (462)

Hypotheses 6 & 7. Roles that students adopt in feedback events, as measured by *response* and *question balance,* are related to student self-worth as measured by score in the class.

Cross tabulations and chi-square tests of significance were conducted. These tests determined that there is no significant relationship between student score and the roles played by teacher and student during feedback events. Teachers are sharing roles of information seeker and information holder with their students at a rate that is unrelated to student self-worth level.

Section II - Discussion of Findings

Student score in science is a score well known by each student, updated daily for students to access remotely by computer and well known by the teacher. The teacher gave each student their score. For this dissertation, overall science score is an indication of how well a student desires and has the skills necessary to do well in science class. This student measure, self-worth as a proxy for score in science, is explained as a reliable measure of student status in science or self-efficacy to do well.

What remains of interest is if students with similar levels of achievement receive the same quantity and quality of feedback across classrooms, for teacher feedback is not orchestrated by administrators at the district level, but is instead a series of on-the-fly instructional and conversational decisions made by teachers as independent agents. Feedback factors indicate something about what a teacher believes students need at different levels of

score in their classroom and whether teacher feedback can impact or improve a low score or a low level of self-efficacy.

Although position, which signifies teacher dissatisfaction, sound like something you wouldn't want in your own feedback practice, it is a symbol of thing, it symbolizes a teacher's commitment to feedback that leads to new student thinking or behavior and in this study *Position* is considered a necessary component of good feedback. If teachers do not demonstrate position, or only demonstrate position within the feedback events of one group of students (by level), this is an indication that only certain students are experiencing challenge within in their science studies or that the teacher has singled out a certain group to critique.

For feedback to be effective is must be used as error detection and teachers must take a position on the student work. Doing so is part of establishing a safe environment in which critique is an acceptable activity. Critique is the work of educators who use feedback to detect errors and improve student understanding. When a teacher expresses dissatisfaction to a student they are taking a position on student performance.

Section II – Summary of Results

Although teachers create conditions that encourage students to ask questions, in these feedback practices, teachers built feedback practices unrelated to student sense of self-worth. Students took on the roles of information holder and seeker at rates that didn't correlate to their score in science, a score that had been established over time and was well known by the teacher, and used in these analyses as an indication of self-worth.

Since there was no significant difference in means and variance for the four classes, these groupings of students are considered samples from a common population and undistinguishable by self-worth. In other words, the level of student self-worth is comparable across the four classrooms and no one class of students is identifiable from the other.

Analyses determined that in these teacher feedback practices, no significant relationships existed between the length of conversation and quantity of conversations that students engaged in with their teacher. This sample of teachers is doing an equitable job of distributing their feedback conversations to students at all levels of self-worth.

However, it was found that student self-worth related to the likelihood that reasoning took place during feedback conversations and so students with low self-worth experienced reasoning at half the rate of high self-worth peers. In addition students with high self-worth were more likely to initiate feedback conversations than peers with low self-worth. This makes sense; students with high self-worth have the confidence to start a feedback conversation and have probably learned how feedback conversations can be used to their benefit.

And finally, it was found that students with low self-worth experienced a higher proportion of teacher dissatisfaction in feedback and a lower percentage of reasoning, so that teachers are not expressing their dissatisfaction in ways that correspond to constructivist activity or reasoning. This finding was suggested earlier in Section I when it was learned that reasoning and critical position happen so infrequently, and yet they still expressed an inverse relationship. Reasoning and position were found inversely related which suggests that

position was used by teachers for purposes of classroom management and not for inquiry. This final Section II finding is that students with the lowest levels of self-worth experienced the greatest percentage of dissatisfaction from their teacher and that critical position, that rarely occurred, was found inversely correlated to reasoning or the activity of teacher and student working together in conversation to express and construct new understandings.

Section III - Test of Teacher Effect

Considering teacher variations in feedback practice. The following seven charts allow a visual opportunity to consider the range of teacher values for each of the qualities or factors documented for each of the teachers' five lessons. In each of the following charts, average lesson scores have been sorted from least to greatest and plotted. Because of this the most left points are the lowest average scores on that factor for each of the four teachers and the right most points are the highest average scores for teachers on that feedback factor. It can be learned from these visual representations that teachers working in tightly coupled conditions with carefully regulated curricular requirements manage to create a feedback practice that is unique from their colleagues experiencing similar conditions.

Charting the average score for teachers on the feedback factors makes it possible to visually compare the average lesson score on a factor by teacher, a process that invites busy educators to reflect on their practice because it requires little time and special training to do so. This accessible process allows teachers to inform their own hypotheses related to teacher practice and feedback factors and focus their inquiry on data that is of the most interest to them.

My theory is that a teacher's feedback practice has been established and that there are measures that can be taken of it and used in formative ways to compare teachers to each other and over content. This study was conducted in the spring, which allowed teachers to know their students for over 6 months. Relationships between students and teacher had been developed and student achievement was understood by teacher. Because of the timing of this study, student measures were stable and, from this, I theorize that teachers had been given the time the needed to establish their feedback practices with their students.

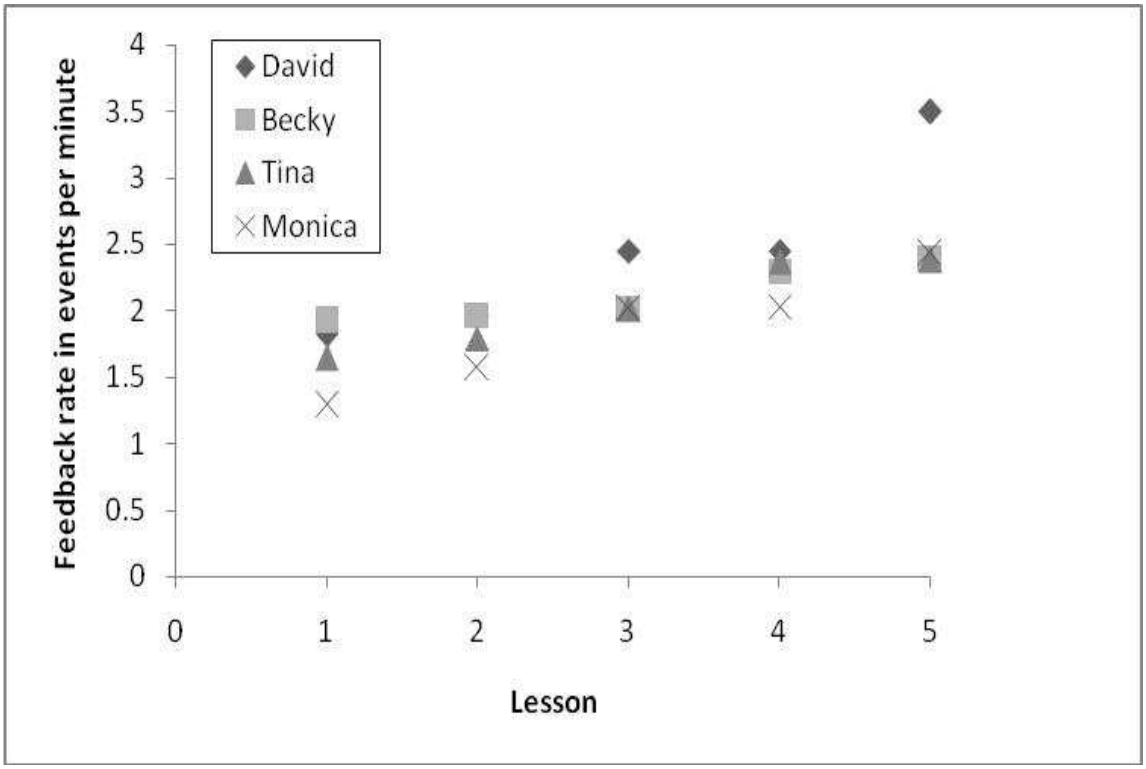

Figure 4.4 - Rate of feedback

The rate of feedback appears very similar across teachers. Monica demonstrates a lower than average feedback rate compared to her colleagues while David's highest value appears to be an outlier, greater than the other teachers. During this lesson, David passed back student work that he had kept for some time, so each paper delivered was coded as a feedback conversation even though it was didactic and had a length of 1 move. A teacher who does not distribute papers, but leaves them in a common outbox for students to retrieve on their own, would receive a lower score for feedback rate. Overlooking David's largest score, the rate of feedback appears similar and stable among these 4 teachers, hovering between 1.5 and 2.5 feedback conversations or events per minute.

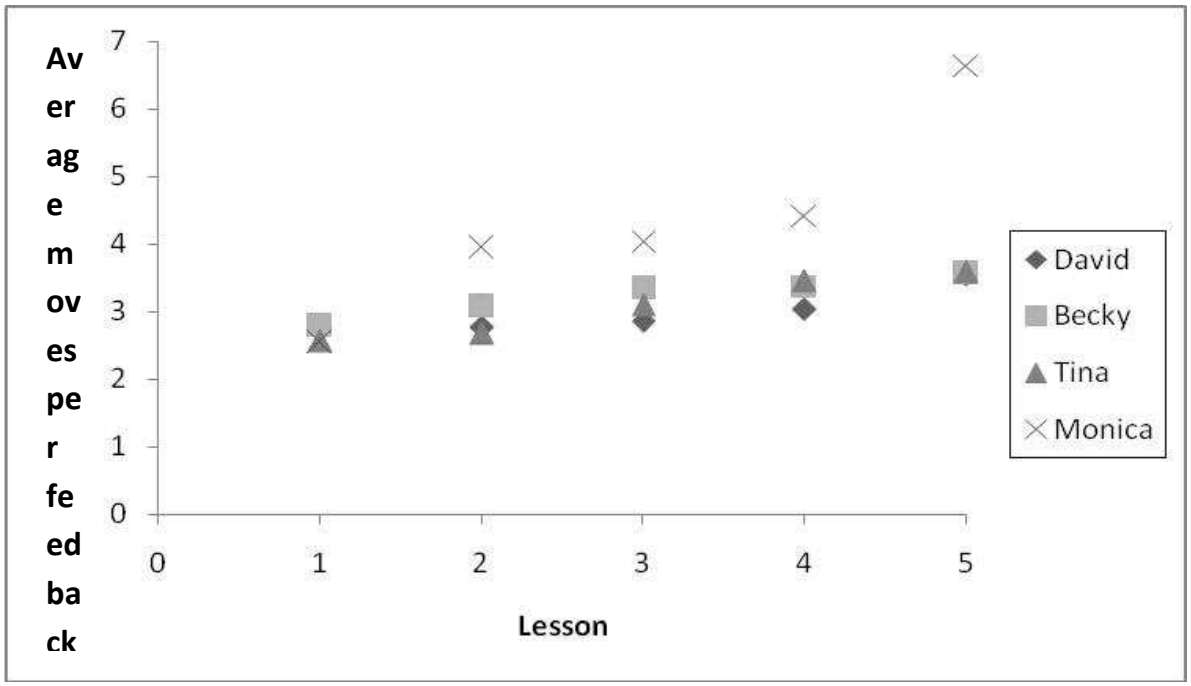

Figure 4.5 - Average number of moves per feedback conversation

The average number of turns per feedback conversation by lesson was arranged from least to greatest (*see Figure 4.5).* Of interest is that while Monica's rate of feedback appears to be lower than her colleagues *(see Figure 4.4)*, her scores on number of moves per feedback event are higher than other teachers. Considering the measure of these two factors, it is suggested that the feedback rate of a teacher is inversely related to the average number of moves per feedback conversation and teachers who engage in fewer feedback conversations with more moves, more back and forth exchanges, probably spend more time with each student on average during their feedback conversations. Becky's score for average number of feedback events stays very stable over the 5 lessons and is slightly higher than David and Tina who tend to engage in the shortest feedback events as measured by number of moves. [12]

[12] Data is presented in this way to allow for accessible and efficient visual comparisons of teachers by feedback qualities and to make formative information available to teachers who want to make changes to their feedback practice.

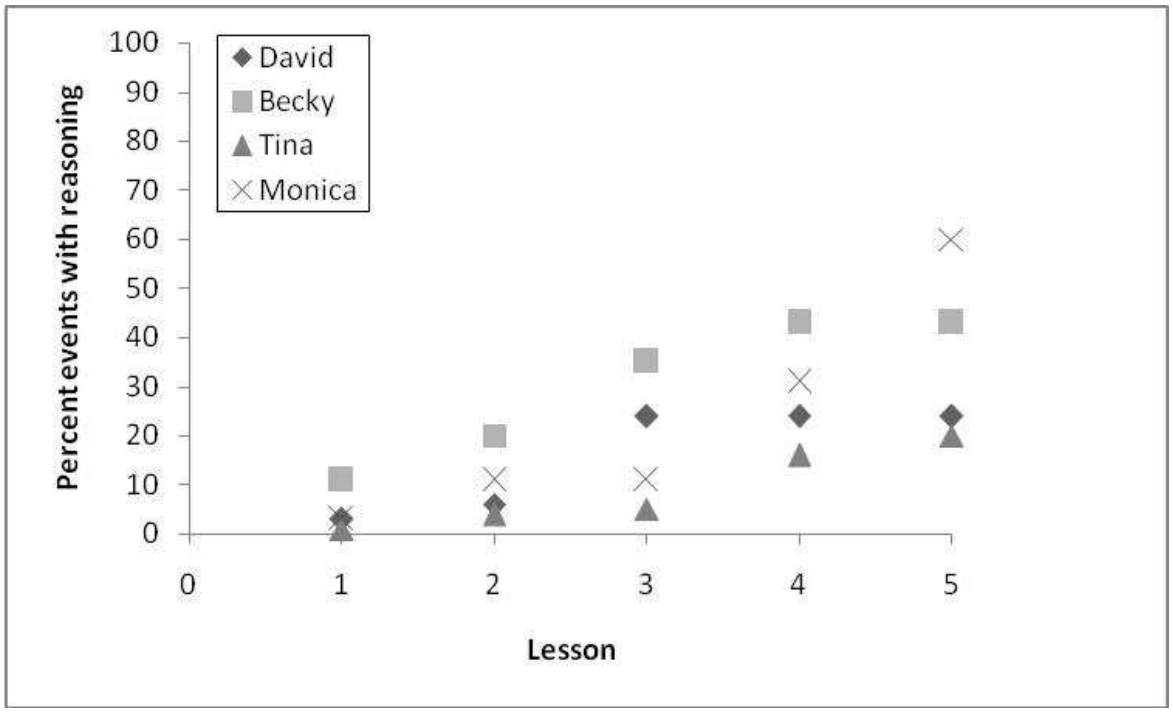

Figure 4.6 - Percent of feedback events with reasoning

Every feedback conversation was coded for *reasoning*, as a dichotomous indicator (*see Figure 4.*6). A feedback conversation was scored for *reasoning* if either the teacher or student asked a new question, included new information that is not didactic by nature or applied their original understanding to a new question or situation. The operative word for this indicator, *reasoning*, is "new', symbolizing an understanding that has not been expressed before, and that is not a directive from teacher to student.

Reasoning is represented by percentage. Tina's lowest score is near 1% meaning that for every 100 feedback conversations only one involved *new* information that represented constructivist learning during conversation.

The most striking observation is the range of scores for the quality *reasoning* and how rare the experience of *reasoning* was found to be in some teacher feedback practices (*again see Figure 4.6*). In fact, *reasoning* received extremely low values for all teachers, but scores were especially low for Tina and David. For *reasoning*, many scenarios qualified. A student could ask a question that required the teacher to add new information or a teacher could ask a student what they thought might happen if a variable was manipulated. These situations were coded for reasoning. Coding rules detected *reasoning* any time new information was exchanged, whether or not information was related to the science topic being studied, e.g., in one feedback conversation the student could not return after school to make up a test and so the teacher and student used that conversation to negotiate a new meeting day and time. Under these broad coding rules, raters were able to detect the slightest involvement of teacher or student in the activity of *reasoning* and even so, many lessons received such low scores for *reasoning*. Becky's classes scored the highest overall for reasoning while Tina's lessons had the greatest percentage of feedback events that with didactic information exchanges, that which has been said and heard before (*see Figure 4.6).*

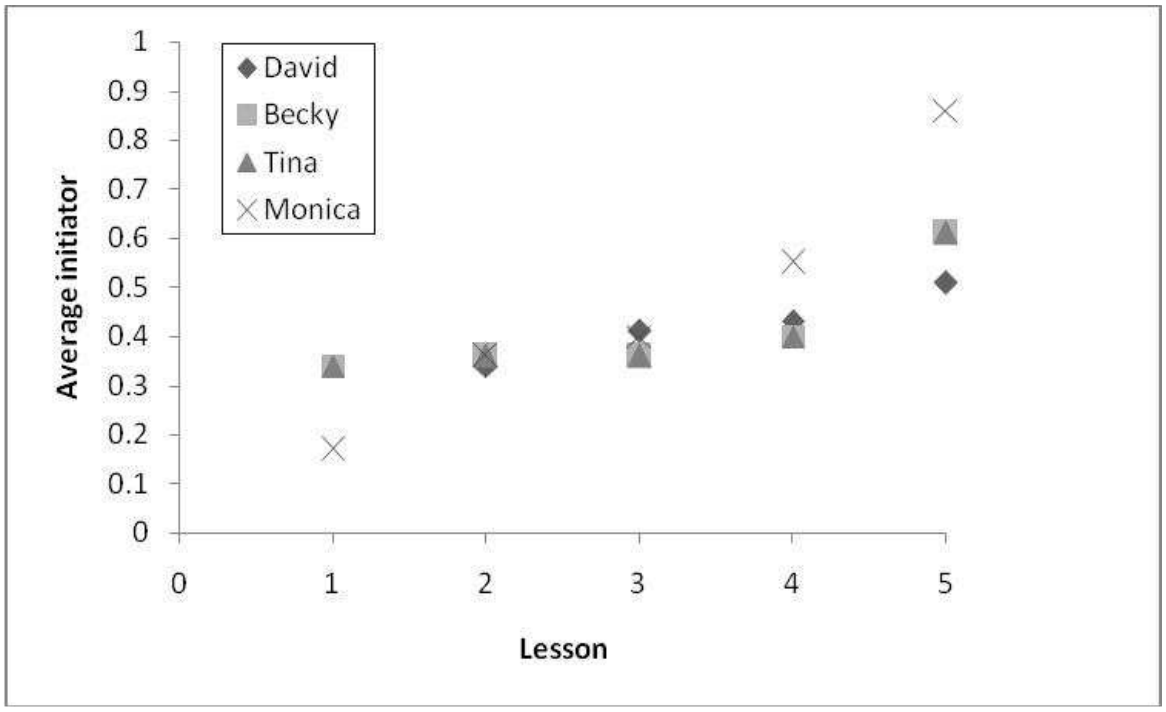

Figure 4.7 - Average feedback events initiated by student

Every feedback event was coded for *Initiation* or who began the feedback conversation (*see Figure 4.7*). The degree to which students initiate feedback with their teacher may be an indicator of whether or not students feel that carrying on a conversation with the teacher is a safe and welcome activity. Feedback conversations were coded "1" for initiation if the student approached the teacher and "0' if the teacher was the initiator. These values were averaged over the total number of feedback events per lesson, per teacher to arrive at an indicator of student initiation during each lesson. Becky, Tina and David are very similar in the degree to which students initiated feedback events during their lesson. Monica's lessons varied the greatest on this quality.

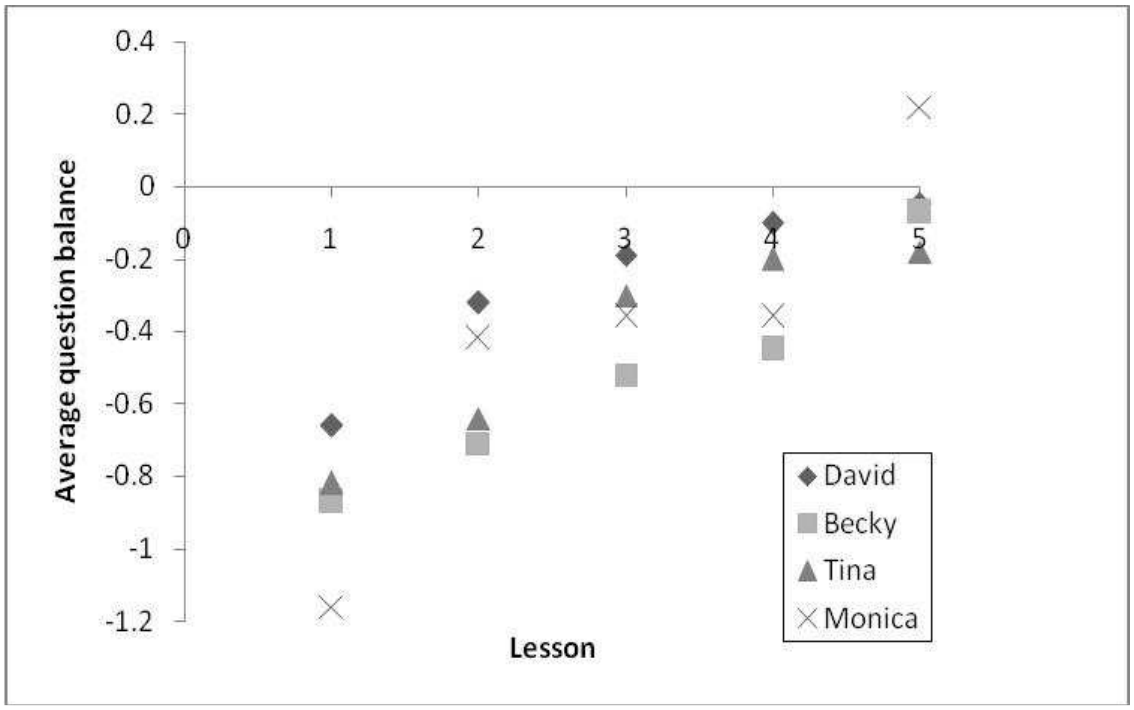

Figure 4.8 - Average question balance

For each feedback conversation, the number of student and teacher questions were counted and *Question Balance* was calculated by (*number of student questions – number of teacher questions*). A positive number indicates that more questions were asked by student than teacher and, when this is the case, the student is playing the role of information seeker in that feedback conversation. A negative value indicates that the teacher was the information seeker in the feedback event. An average was taken for *Question Balance* across all feedback events per lesson (*see Figure 4.8*) and shows that in only one lesson, Monica's lesson, the students assumed the role of information seeker. In all other 19 lessons, the role was played by the teacher.

Question Balance and *Initiation* are indicators of classroom climate and expectations teachers and students have for each other during the learning process. It could be that teachers who ask more questions than students and assume the role of information seeker model questioning practices, intending to demonstrate for their students what motivation looks like and how to be inquisitive. Or, it could be that teachers who ask more questions than their students are communicating to their student that they need to depend upon the teacher for information. Knowing why feedback events heavily favor teacher as information seeker is, unfortunately, beyond the scope of this study, but teachers who are able to learn this information about their own practice then have what is needed to reflect and explain it.

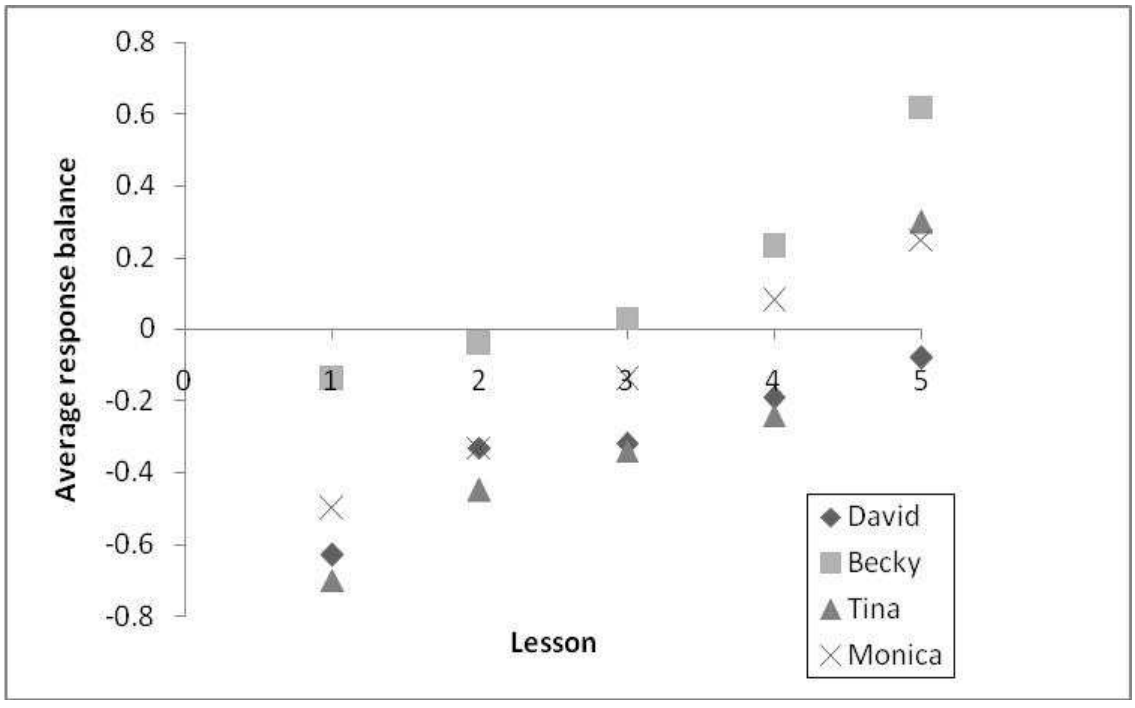

Figure 4.9 - Average response balance

For each feedback conversation the number of student and teacher statements or responses was counted and *response balance* was calculated by (*number of student responses – number of teacher responses*) as an indication of the role information holder (*see* Figure 4.9). Students assumed the role of information holder and provided more responses than their teacher in 6 of the 20 lessons coded. In most of Becky's lessons, and as an average of all conversation, students assumed the role of information holder. On average, students did not take on the role of information holder during any of David's lessons.

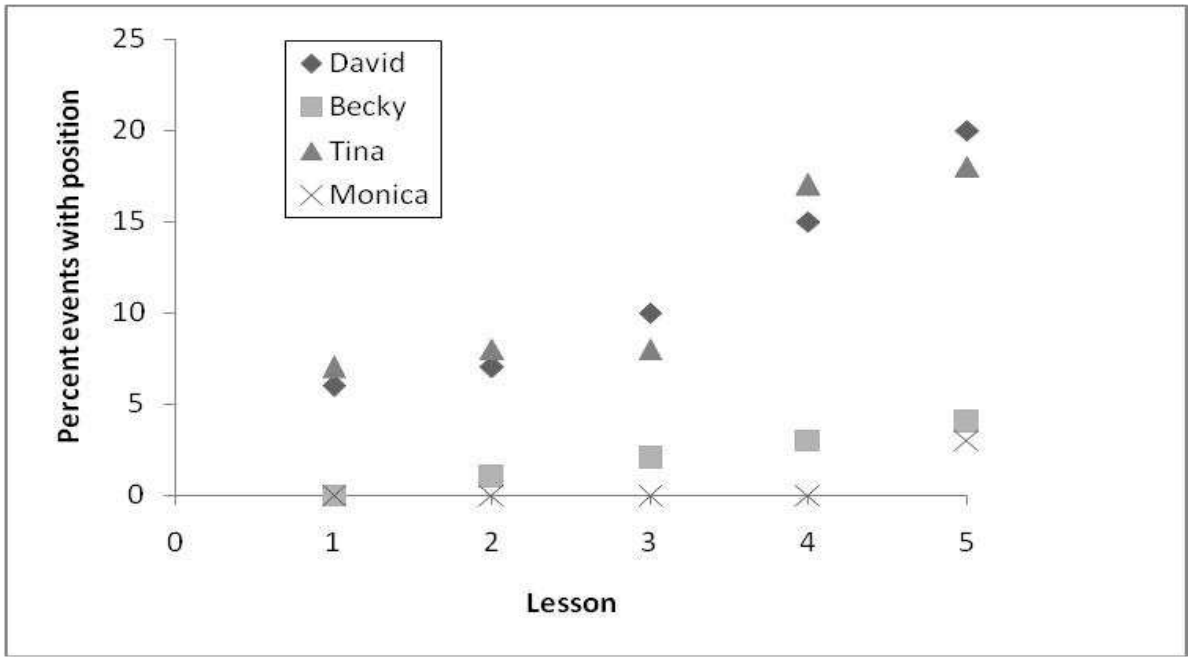

Figure 4.10 - Percent of feedback events with position

Finally, the feedback factor, *position*, is used an indication of teacher expression of dissatisfaction during a feedback conversation. Although dissatisfaction sounds quite

negative, it is an indication of error detection which has been shown in the educational literature to be powerful and necessary when correcting student misconceptions, a trademark of constructivist learning (Hattie & Timperley, 2007). Teachers can express dissatisfaction in student work, attitude, response or action. As with *reasoning*, *position* is coded reliably, but it does not discern between types of teacher dissatisfaction and the reason why a teacher took on a position of dissatisfaction. For example an event was coded for *position* when the teacher asked a student to move to a new seat because she was talking too much with peers during whole group instruction and, in another case, a conversation was coded for *position* because the student's response to the teacher's question was only partially correct and the teacher expressed that something was missing and she wasn't fully satisfied, e.g. "Good answer, but…." The number of feedback conversations coded for *position* or expression of teacher dissatisfaction were counted and averaged per lesson over total number of feedback events. On average, lessons received very low averages of teacher dissatisfaction during feedback conversations. For example, in four of Monica's five lessons she expressed absolutely no dissatisfaction to her students *(see Figure 4.10)*. Becky also had a consistently low average for the factor *position*. Tina and David demonstrated similar averages for expressing dissatisfaction to students in feedback conversations, between 5 and 20 percent of all feedback events. As earlier tests showed (*see Section II of this chapter, Test 5)* low achieving students experience the greatest proportion of teacher dissatisfaction as coded by *position*. Is this because low achieving students have the greatest misconceptions and errors that need detecting or is there another reason that teachers express their dissatisfaction more easily with

low achieving students, as measure by student score in their class? Because student with low self-worth experience half of the rate of reasoning in feedback conversations, it appears that *position* or teacher expression of dissatisfaction is used as a management tool, rather than a method for leveraging reasoning or constructivist thinking.

Students with a high sense of self-worth are more inclined to initiate feedback conversations with their teachers. However, after initiating the feedback conversations, sense of self-worth does not impact the likelihood a student assumes the role of information seeker or to experience longer feedback conversations or experience more feedback conversations with the teacher. Within these feedback practices, and looking at the data across teachers, on the surface, students with high self-worth are not experiencing feedback that is very different from peers who have low levels of self-worth. However, students with the lowest levels of self-worth are half as likely as their peers to experience reasoning during a feedback conversation.

One hypothesis and finding.

Hypothesis 1 - Analysis of teacher effect on score by student interaction. As all these graphs show (*see Figures 4.4 – 4.10*), teachers demonstrate individuality in their feedback practice. In Section II of the analysis, interactions exist between student score and feedback factors *reasoning, initiator and position*. This final analysis seeks to understand if there exists a teacher effect by way of an interaction between student score and reasoning. The hypothesis is that the degree to which student self-worth relates to likelihood of feedback conversations with *reasoning* can be explained by knowing the teacher, for teacher is the architect of the

learning environment and feedback conversations remain a uniquely independent activity of a teacher, regardless of how tightly curriculum is controlled by outside administrators.

It is hypothesized that although student score impacts the likelihood that reasoning will occur during a feedback conversation, the teacher, himself or herself, has the power to mitigate this effect. Teachers create unique learning environments so that students who are not normally engaged feel confident and become attentive and engaged. A teacher effect found in the interaction between self-worth and reasoning during feedback conversations would indicate that teachers have impact the degree of constructivist thinking that students experience and that this happens regardless of score, with the result being that students who normally display lethargy toward learning science demonstrate interest and are more likely to prompt engage with their teachers in reasoning, exposing new thinking.

Coding rules for *reasoning* in a feedback conversation only detect when new thinking happens and not from where it originated - teacher or student. However, a teacher effect on the interaction between *self-worth* (or *score*) and *reasoning* would imply that teachers have impact on the degree to which *reasoning* and *score* are related. Log-linear analysis was used with a contingency table to test for significance within interactions (*see Table 4.13*).

Table 4.13 - Contingency Table - Teacher x Score Level x Reasoning

	Without Reasoning				With Reasoning			
	Teacher				Teacher			
Score level	1	2	3	4	1	2	3	4
1	184	39	100	42	27	7	8	5
2	84	81	92	70	21	40	12	11
3	38	42	150	70	10	28	16	26
4	130	106	69	48	31	47	5	14

The analysis show, $G^2 = 23.34$, df = 12 and 21 is the critical value, so it is determined that there exists a teacher effect in which the interaction between student *score* and *reasoning* is found to be dependent upon the teacher (*see Table 4.14*).

Table 4.14 - Results from Log Linear Analysis - Counts for Score, Teacher and Reasoning

Interaction	G^2	df	Sig.
Score x Teacher x Reasoning	341.72	24	<0.0001
Score x Teacher	249.06	9	<0.0001
Score x Reasoning	20.7	3	<0.0001
Teacher x Reasoning	69.32	3	<0.0001
Score x Teacher (reasoning)	251.7	18	<0.0001
Score x Reasoning(teacher)	23.34	12	0.025
Teacher x Reasoning(score)	71.96	12	<0.0001

Revisiting Chapter Findings

Teacher conversations with students tended to be short and the longer the feedback event, the more likely it was to involve reasoning. Within a feedback event, the teacher was found to be more likely than the student to assume the primary role of questioner and it was learned that information seeker and information holder are distinct and opposing roles, adopted distinctly by teacher and student within feedback conversations, and especially true when the teacher takes on the role of information seeker.

Teachers initiate most feedback conversations and rarely express a critical position to their students in conversation. When they do take a position or express dissatisfaction, the conversations was found most likely to be initiated by the teacher. Only one in five of all feedback events were found to include reasoning or constructivist thinking, but when it happens it is most likely that the teacher played the role of primary questioner. This implied that the teachers was driving the condition that led to higher level thinking within a feedback conversation, and yet are doing this for reasons closer to classroom management, and holding back on expressing dissatisfaction that would leverage reasoning or new thinking.

Teachers initiate conversations more than their students and their expression to their students of any type of dissatisfaction or critical position is rare. Teachers do not use feedback conversations as a method for communicating error detection, for if they did, they would be required to take a position on student thinking which was not done, even in the most respectful and considerate manner. While feedback conversations were more likely to involve

reasoning when the student involved had high learner self-worth, students with low self-worth were more likely to experience teacher position or expression of dissatisfaction.

So teachers are reserving their critical position for students with the lowest sense of self-worth and are engaging in reasoning at a greater rate with students who have the highest sense of self-worth. From these findings, it is clear that in the case of this sample, reasoning, a sign that knowledge is being constructed, and position, a symbol of error detection, were not found to be complimentary activities for they did not occur together during the same feedback conversations. These feedback conversation qualities were found related to student self-worth.

The fundamental premise of this study is that teachers act as independent stimuli producers for their students and agents of feedback, continuously and systematically building a practice that, to be most effective, must be sensitive to the way each student feels about himself or herself as a learner of science, including how much dissatisfaction they communicate with each student as well as the opportunities they make for shared reasoning during feedback experiences. Teachers are called to build an informed, systematic feedback practice that reflects all they value regarding what it means to learn and engage in science. The best way to support effective teacher feedback practices is to offer teachers reliable, feasible, believable and useful information about what it is that they are doing in in their practice.

Finally, different students have different experiences with teacher feedback. There are students in each class that remain strangers to conversations with their teachers, even conversations of one move that exist to issue the student a directive. These are the forgotten

students who sit for a week's time in science lessons and have absolutely no interaction with their teacher, and never even ask if they can use the restroom or find themselves being acknowledged for their presence in the classroom. These are individual students with unique experiences and independent reasons for lacking teacher interest or engagement. They are experiencing neglect. Teachers should be able to identify not only who the forgotten students are, but offer a reflection on this and explain why it is so. The dissertation study is a form of diagnosis or description that explains what is happening within a teacher's feedback practice and in relation to each student. It provides information for teachers about how each student experiences feedback conversations and how this is evidence of the teacher feedback practice they are establishing.

During feedback conversations, if a student is not assuming a strong role in the feedback event, the teacher will assume the role of information seeker and ensure that the student gets involved. If this didn't happen, the teacher would assume both roles by asking and answering his or her own questions, something that is not supported by these data. In a traditional teacher-centered classroom, it would make sense that the teacher assumes a role that drives the student to participate. Under this circumstance, the student engages with the teacher as an equal and does not drive the conversation.

Chapter 5: Discussion

Overview

This dissertation study explains teacher feedback by examining all conversations that occur between teacher and student, embedded in classroom instruction. Each feedback conversation was coded for six qualities to understand relationships between qualities, the likelihood that these qualities would occur and how they were distributed in feedback over students. The overriding research question was crafted to understand how student sense of self-worth relates to the qualities of feedback conversations and whether teachers reserve an amount or type of feedback for students related to their level of self-worth.

Study methodology allowed for understanding student experience with teacher feedback as it relates to the overall score they have in the class, an indicator of a student's sense of self-worth as a science learner. The qualities of interest tie back to earlier educational research and can be reliably coded and clearly and efficiently communicated. *All* feedback conversations in this study (n = 2021) happened over five successive lessons of four teachers and every one was coded and analyzed. Data or the codes from these conversations were used to explain how often certain qualities happen in the feedback practice of a teacher and how often they were experienced by different students. What matters most in learning, student self-worth or how a student feels about himself/herself as a science learner, was used to identify different types of learners in each class.

Review of Findings

Analyses of all feedback conversations revealed that some qualities of feedback are equally distributed over all students regardless of self-worth, and these include how much feedback, length of feedback conversations, and roles played by students within feedback conversations. It was found that students with high self-worth engage in feedback conversations with their teacher at the same rate and for the same duration of moves as students with low self-worth. It was also found that students, regardless of self-worth, took on the role of information seeker and the role of information holder at similar rates. However, there were differences found in feedback conversations between students with low levels of self-worth and those with high levels of self-worth. These qualities were reasoning, critical position and initiation. For students with low levels of self-worth, reasoning or the activity of constructivist thinking was less likely to happen. These learners were less likely to initiate a feedback conversation and more likely to experience critical position or teacher dissatisfaction in feedback. Students with high levels of self-worth initiated feedback conversations with their teacher at a greater rate than their lower self-worth peers.

Feedback conversations were found to be short and constructivist thinking or reasoning was more likely to happen the longer the conversation. In this study, effective assessment was conceptualized as reactive to student understanding, taking place as an unscripted experience. Feedback that spurs deep-thinking engagement finds both teacher and student in a vulnerable position. Learning environments that allow for this type of vulnerable engagement require transparency in communication about what is expected and valued during

feedback. And this happens over time and is a part of the feedback practice that a teacher builds. In a teacher's feedback practice, transparency is evident when teachers and students share emergent thought in unscripted ways, feel that it is acceptable to be wrong or to have misconceptions, and when this happens, feedback conversations tend to be longer. Longer feedback conversations are evidence of student willingness to share ideas as they emerge, knowing that it is valuable to engage with their teacher for the purpose of constructing or developing new knowledge.

Analysis showed that teacher and student took opposing roles during feedback conversations and the teacher was most often in the role of information seeker. It was under this condition that reasoning emerged within the conversations. When feedback events were question-driven by the teacher, reasoning happened one third of the time. And yet, when the student acted as the main questioner reasoning was much less likely to occur. From this it appears that teachers who are driving feedback conversations with their questions introduce reasoning conditions and that teachers have the skill to do this. And yet, conversations that involve reasoning are not frequent and not standard practice in feedback.

Zero feedback events. In each of the classes that participated in this study, there were students who sat through an entire class period without engaging in a single feedback conversation *(see Table 5.1, below).* Every feedback conversation was coded, even those that were one move commands or directives, such as when the teacher called out the names of students when passing out papers. Within the feedback practice of each of the participating teachers in this study there were students who experienced zero feedback conversations over

one or more lessons (*see Table 5.1, below*). When teachers are provided information about their practice that includes names of students experiencing the condition of zero feedback, a more equitable practice has the chance to develop. Teachers currently do not have tools that allow them to understand the distribution of their feedback conversations.

Table 5.1 - Students with zero feedback events per lesson

Teacher	*Students by number with zero feedback events per lesson*
David	114, 114, 116, 119, 119, 125
Becky	207, 208, 209, 210, 210, 212, 215, 215, 216, 218, 224, 226, 227
Tina	302, 305, 308, 309, 324, 325, 326
Monica	408, 411, 418, 420, 423, 426, 427, 427

Limitations

This dissertation study describes a process for understanding a teacher's feedback practice in terms of qualities of feedback conversations and how conversations are distributed over a class of students as they relate to student sense of self-worth. It is a descriptive study and so it has limited predictive value. Findings from the feedback practices of these four participating teachers cannot be used to predict outcomes for other teachers. The power of this process is formative, producing information with value to teachers about their own feedback habits.

Confoundedness of study findings. It has been noted that feedback in student learning can originate from anywhere including from a book, the environment or from peers (Hattie & Timperley, 2007). Students have learning conversations with peers during instructional time and outside of the classroom, as well. However, this study is not designed to understand all possible learning conversations. It is a study that places the teacher at the center of and fully responsible for building a feedback practice comprised of their own feedback conversations that take place during instruction and that involve one student at a time. This is a study that has been purposefully narrowed exclusively to what involves teachers or to teacher-student feedback. Many other educational researchers consider much more when they study learning because they see it in terms of interactions. They may be quick to identify the narrow view of this study as a limitation.

But a narrow focus is intended in this study in order to understand what it is that teachers do to build a practice of feedback over student and over time and how they distribute their feedback based upon student self-worth. This study stays true to examining feedback conversations between teacher and student and producing information about the conversational habits of the teacher, remaining disinterested in what happens outside of these feedback conversations. Future research should concern itself with the stability of a teacher's practice over different classes of students and varied lesson topics. Studying what it is that changes in the feedback practice of a teacher over different group of students or lesson topics will allow for knowing other types of information that cannot be addressed by way of this methodology.

In addition, there are many other things that teachers do during instructional time to help students learn. However, again, this study remains narrowly focused on the feedback practice of teachers as defined through their feedback conversations with students. It is purposefully done, to focus teachers on a single aspect of their profession and provide them information they need to understand what they are doing, reflect and make meaningful change. This is a focused study and is limited in explaining things about teaching beyond the feedback practices of teachers as they have been defined.

Sampling of lessons. Because the teacher is building a practice of feedback over time, the number of lessons used in this study may be a limitation. There were five lessons coded for each of the four participating teachers and this number could be increased. Increasing the number of lessons beyond five will allow for a reliability study that would explain the stability of these measures on a teacher's feedback practice over time. Knowing how many lessons are required to reach stable outcome measure would support more valid claims about the feedback practices of participating teachers.

Beyond formative and study implementation. The motivation for this study is in producing feasible and believable information for teachers about their own practice that allows a teacher to understand what it is they are doing and how it is experienced by different learners in the classroom. The strength of any evaluation is in the degree to which it is considered a formative process. So, for those who may wish to use this in a summative way, the limitations that exist make it prohibitive.

Recommendations for the Future

Learners are individuals who begin the active construction of knowledge at different starting points, so the work of a teacher must be individualized for unique learners and this makes the work of teaching and of building a feedback practice challenging and remains the origin of many teaching dilemmas; it is an ongoing struggle for teachers to meet the needs of individual learners while moving the entire class of students forward. Managing this tall order requires teachers who are constantly engaged with students and regularly reflecting on their interactions with students and ready to explain how they distribute feedback effectively and fairly to their students. The degree to which teachers can do this indicates the quality of their feedback practice and their individuality as a teacher.

This descriptive dissertation process provides an example of how teacher feedback practice can be understood in terms of student experience with teacher conversations. And the exercise can be applied to any teaching practice, for it produces formative feedback for teachers in any classroom, teaching any subject or content. Teachers can use outcome measures on the qualities of their feedback to make new and better informed decisions in the way they interact with students at varying levels of self-worth in the class.

Education budgets are tight and there is increasing urgency to create formative assessment systems for teachers to analyze what they do during lessons and make evidence-based instructional decisions. Teacher feedback practice involves all conversations that take place during the lesson between teacher and a single student and so the elements of these conversations can be *mapped* back to individual students so to understand the experience of

each student with teacher feedback. *Feedback Mapping* happens in real time if conducted by a trained observer and requires no transcription. Every feedback conversation can be easily represented using symbols and coded for six qualities. The coding process produces ordinal or count data on six factors and is information for teachers about their feedback practice, or feedback about teacher feedback. Teachers can be trained to code feedback conversations for themselves and encouraged to ask their own questions about their practice, establishing new qualities that have not yet been identified or named.

Formative feedback for teachers. Capturing and understanding teacher feedback has power only as a formative activity, and this is the main recommendation of this dissertation study. Coding each feedback conversation allows a teacher to know about their own practice and how they distribute feedback to students as it relates to student self-worth. As interesting as anyone else might find study findings, it can be presumed that no one is more interested in these data than the teacher from which the data came. It is teachers in classrooms that are most eager to understand their feedback practice and for this, a feasible and objective process, such as Feedback Mapping, is required. Feedback Mapping provides teachers information about their own practice and is an objective process for looking at what it is that they do during their lessons, supporting them in making new instructional decisions.

Every instructional moment counts during a lesson and every opportunity to engage students in meaningful feedback conversations must be seized. Given the information, many teachers understand this and build a very interactive feedback practice, reaching all students. This quality of a teacher's practice is illuminated by Feedback Mapping. Feedback

conversations over the course of a lesson can engage all students and expose each one to the activity of reasoning. Feedback Mapping is a measure of teacher equity in the learning process. Teachers who build effective feedback practices use conversations with students as opportunities to invite students into the learning process and improve self-worth as science scholars. It is the recommendation of this study that the process of data collection for understanding teacher feedback or Feedback Mapping remains a personal, individualized effort to engage teachers in understanding, explaining and improving their own feedback practice.

Teachers as the agents of their own practice. Findings from this study show teachers are the ultimate decision makers regarding the crafting and implementation of the most powerful aspect of their profession, teacher feedback. Teachers create a distinct and individual feedback practice as shown in the analysis of their conversations with students, and this is the case even under increasing pressure to streamline what they do and deliver lessons that look more and more like the teacher next door. It is the position of this dissertation study that teachers are ultimately responsible for understanding why individual students participate in learning or refrain from participation. Teachers must know which students are avoiding interaction and build and test their own theories of why it is happening. And to do this they will need tools. This study introduces a feasible tool that provides reliable data on teacher feedback, communicating what needs to be known for teachers to understand and inform their own feedback practice.

Affording teachers reliable information on their own practice allows what is needed for teachers as the agent of their practice to adjust and leverage greater constructivist thinking within feedback conversations. In order to continue to conscientiously distribute feedback to all students, teachers may find themselves cutting to the chase and engaging directly and purposefully with new ideas, doing so regardless of student score. A Feedback Map of a teacher's instructional performance is the type of personal, targeted information teachers require to turn theory into practice and is required to detect improvement in a practice. The process of Feedback Mapping becomes formative when a teacher can reflect on the map, make adjustments and compare results of maps from subsequent lesson.

The origin of the Feedback Map. Information teachers can use to understand their practice as it relates to the experiences of their students is introduced in this final chapter as a *Feedback Map*, the result of mapping teacher feedback conversations. Creating a feedback map is the culmination of the most important aspects of this dissertation study. Feedback Mapping provides information to those who can use it most, classroom teachers working with the students whose experienced were mapped. This is a teacher's opportunity to examine their feedback practice and understand it by student experience. Information presented in the feedback map was identified by this study as the most meaningful and distinguishable by teacher and student experience. The following is contextual history to explain how the feedback map was created. An example is provided.

While running the video camera and observing lessons during the data collection phase of this study, I began to experiment with ways that conversational information could be

captured in real time – something that is fundamental to providing teachers a feasible method of data collection so to conduct an inquiry on their feedback practice. The initial attempt at this resulted in the first feedback map (*see Figure 5.1*) that captures quantity, student initiation of a conversation and the presence of reasoning.

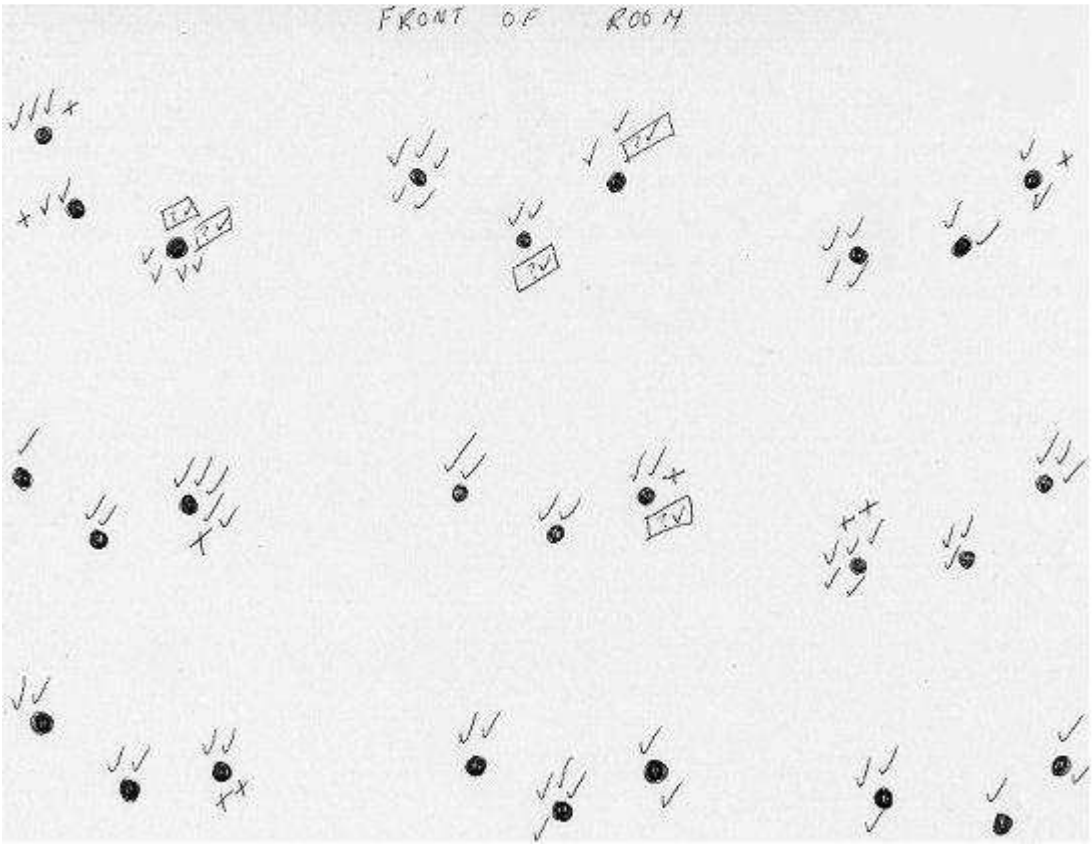

Figure 5.1 – A first attempt at Feedback Mapping.

Feedback Mapping, a tool for formative assessment. Subsequent experiments with this real-time procedure allowed for more detailed information to be included, such as who initiated each feedback event and its length in number of moves. Educational research and

results from this study indicate that the presence of reasoning is important in understanding the feedback practice of a teacher and student experience in those conversations and that reasoning is related to student sense of self-worth. If feedback maps to what teachers already know or believe about their students, then conversations are doing nothing to change or improve student self-worth. The number of feedback conversations that a teacher can engage in during a lesson must be a finite number, and so the teacher needs to consider how equitable his/her feedback moves are distributed to students and be able to rationalize their distribution. The rate of teacher feedback is high in this lesson mapped (*see Figure 5.2*).

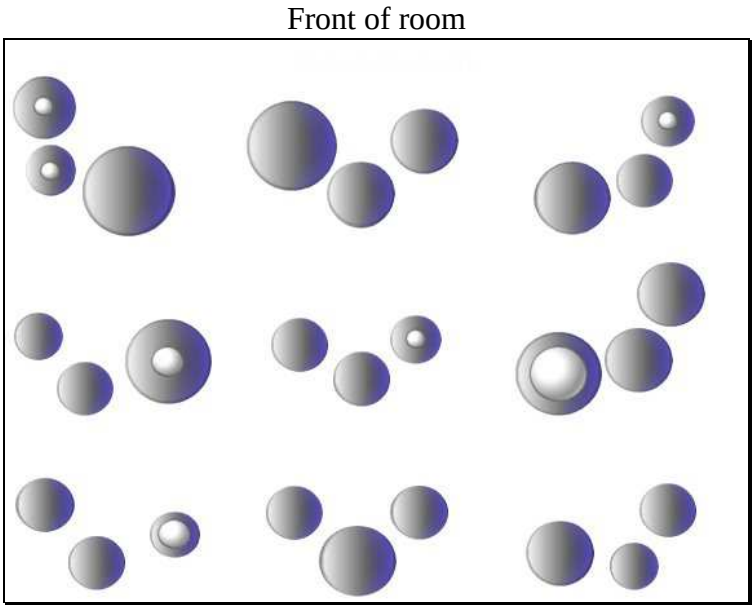

Figure 5.2 – Information presented as a Feedback Map.

Each student is represented by a circle. The size of the circle indicates the number of feedback conversations that they engage in with their teacher. If the student experiences reasoned thinking during a feedback conversation, a white center is included which represents the proportion of total conversations that involved reasoning. In this first lesson, constructing knowledge or reasoned thinking is rare in these feedback conversations.

Imagining another lesson in which teacher feedback was distributed in essentially the same way but in which the feedback conversations involved more reasoned thinking leads to a Feedback Map with different affect (*see Figure 5.3*).

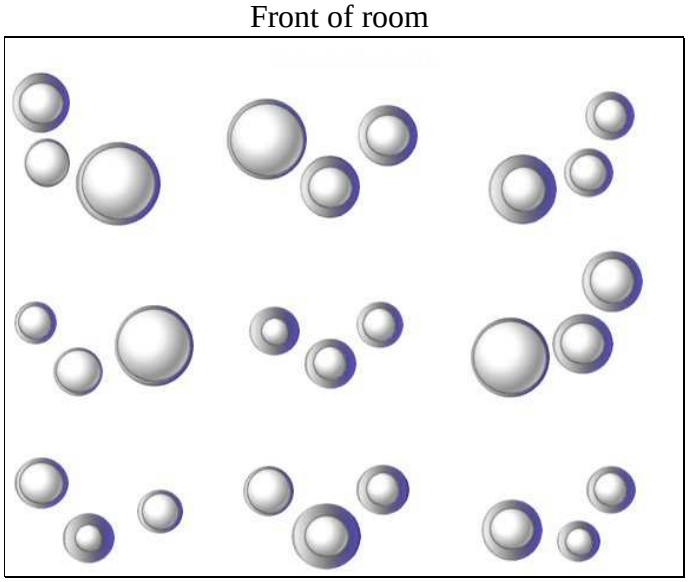

Figure 5.3 – Feedback Map with greater incident of reasoned thinking.

Just as with all assessments, Feedback Mapping holds power for learning communities only to the extent that it improves teaching and supports learning (Brookhart, 2009; Mory,

2003; Wiliam, 2011; Hattie & Timperley, 2007). Feedback Mapping, as with any type of assessment, offers support to the learning process only when it is treated as a formative system in which teachers learn about their own teaching by being provided information that exposes the gap that exists between what is and what could be (Ramaprasad, 1983). It is the formative aspect of evaluation and assessment that holds hope for improved classroom learning (Sadler, 1983; Black, 1986; Black & Wiliam, 1998). Feedback Mapping provides teachers real-time objective information about what it is that they do. To retain power, it must remain purely a formative tool and should never be used to determine teacher salary or to recognize, reward or punish teachers. To use it for these purposes would render the process powerless and do more harm than good to teaching and learning.

Final Thoughts

Brookhart (2004) found that feedback should focus on information that draws students to things they can act upon, happen sufficiently and frequently, be motivational and encourage thoughtful reception. This is the case, as well, when it comes to providing feedback for teachers about their own teaching. Teachers can only use feedback when it contains information that draws them to the things they do, behaviors they can change or act upon. When feedback is this type of information for teachers, then it is of value, it is motivational and leads to thoughtful reflection. It will be in feasible processes, accessible and meaningful to classroom teachers that instructional practices will improve.

Over the many years of educational research on feedback, what it means to learn has evolved, taken on new understandings to have included everything from memorization to

metacognition (for review see Hattie & Timperley, 2007; Mory, 2004; Shute, 2008). Ways of conceiving of learning today are often presented to practitioners in very involved terms. When learning is made overly complex, reliability in studying it is compromised and validity suffers (Wiliam & Black, 1996). So to be effective in studying feedback and communicating results, learning has to be explained parsimoniously. If teachers are to feel invited into a process of inquiry about their own feedback practice, feasible, parsimonious tools that capture personal data must be developed and supported. Formative assessment is the necessary process that gives teachers information about what they care about within their own instructional practice and it steers clear of theory that isn't testable, such as theories about other teachers' practices. Complexity introduced in educational research will always be the prohibitive obstacle for teachers in advancing their practice and making it more effective. Feedback Mapping provides teachers an objective look at what they are doing, inviting and involving them in mindful reflection that leads to a more effective practice, for today and in the future.

And to gain even greater power in this professional formative process, teachers, the architects of their own feedback practice, must be provided opportunity and training, and be encouraged to identify and code qualities of their own feedback conversations, qualities that have not yet been identified and studied. It is this type of professional endeavor, rooted in classroom experience and dependent upon reflective inquiry that positions teachers as the most interested in and expert when it comes to the construction of their feedback practice, and it is this professional activity that will produce the greatest benefit for students and for us all.

References:

Ames, C., & Archer, J. (1988). Achievement goals in the classroom: Students' learning strategies and motivational processes. *Journal of Educational Psychology, 80*(3), 260-267.

Anderson, L. W., Krathwohl, D.R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives.* New York, NY: Longman.

Anderson, J. R., & Lebiere, C. (1998). *The atomic components of thought*. Mahwah, NJ: Lawrence Erlbaum Associates.

Assessment Reform Group (1999). *Assessment for learning: beyond the black box.* Cambridge, University of Cambridge School of Education.

Atkin, J. M., Black, P., & Coffey, J. (2001). *Classroom assessment and the national science education standards.* Committee on Classroom Assessment and the National Science Education Standards. Washington, DC: National Academy Press.

Bailey, K., & Jakicic, C. (2012). *Common formative assessment: A toolkit for professional learning communities at work.* Bloomington, IN: Solution Tree Press.

Bandura, A. (1977). *Social learning theory*. Upper Saddle River, N.J: Prentise-Hall, Inc.

Bangert-Drowns, R. L., Kulik, C.-L. C., Kulik, J. A., & Morgan, M. T. (1991). The instructional effect of feedback in test-like events. *Review of Educational Research, 61*(2), 213-238.

Bell, B., & Cowie, B. (2000). The characteristics of formative assessment in Science education. *Science Education, 85*, 536-553.

Bell, B., & Cowie, B. (2001). *Formative assessment and Science education.* Dordrecht: Kluwer Academic Publishers.

Black, H. (1986). Assessment for learning. In D. L. Nuttall (Ed.), *Assessing educational achievement* (pp. 7-18). London: Falmer Press.

Black, P. J., & Wiliam, D. (1998a). Assessment and classroom learning. *Assessment in Education: Principles, Policy & Practice, 5*(1), 7-73.

Black, P. J., & Wiliam, D. (1998b). *Inside the black box: Raising standards through classroom assessment.* London: King's College London School of Education.

Black, P. J., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability, 21*(1), 5-31.

Bloom, B. S. (1959). Some theoretical issues relating to educational evaluation. In H. G. Richey & R. W. Tyler (Eds.), *Educational evaluation: New roles, new means, pt. 2* (Vol. 68, pp. 26-50). Chicago: University of Chicago Press.

Bloom, B. S. (1976). *Human characteristics and student learning.* New York, NY: McGraw Hill.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

Brookhart, S. M. (2004). Classroom assessment: Tensions and intersections in theory and practice. *Teachers College Record, 106*(3), 429-458.

Brookhart, S. M. (2007). Expanding views about formative classroom assessment: A review of the literature. In J. H. McMillan (Ed.), *Formative classroom assessment: Theory into practice,* (pp. 43-62). New York, NY: Teachers College Press.

Brookhart, S. M. (2009). *Exploring formative assessment.* Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Brophy, J. E. (1981). Teacher praise: A functional analysis. *Review of Educational Research, 51*, 5-32.

Burkam, D. T., Lee, V. E., & Smerdon, B. A. (1997). Gender and Science learning early in high school: Subject matter and laboratory experiences. *American Educational Research Journal, 34*(2), 297- 331.

Butler, R. (1987). Task-involving and ego-involving properties of evaluation: Effects of different feedback conditions on motivational perceptions, interest, and performance. *Journal of Educational Psychology, 79*(4), 474-482.

Butler, R. (1988). Enhancing and undermining intrinsic motivation; the effects of task-involving and ego-involving evaluation on interest and performance. *British Journal of Educational Psychology, 58*, 1-14.

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research, 65*(3), 245-281.

Cardelle, M., & Corno, L. (1981). Effects on a second language learning of variations in homework written feedback. *TESOL Quarterly, 15*(3), 251-261.

Chan, J. C. Y., & Lam, S. F. (2010). Effects of different evaluative feedback on students' self-efficacy in learning. *Instructional Science, 38*, 37-58.

Chin, C. (2006). Classroom interaction in Science: Teacher questioning and feedback to students' responses, *International Journal of Science Education, 28*(11), 1315-1346.

Clariana, R., & Koul, R. (2006). The effects of different forms of feedback on fuzzy and verbatim memory of Science principles. *British Journal of Educational Psychology, 76*, 259-270.

Clarke, S. (2003). *Enriching feedback in the primary classroom.* London: Hodder and Stoughton.

Cowie, B., & Bell, B. (1999). A model of formative assessment in Science education. *Assessment in Education: Principles, Policy and Practice, 6*(1), 32 - 42.

Crooks, T. J. (1988). The impact of classroom evaluation practices on students. *Review of Educational Research, 58*(4), 438-481.

Crooks, T. J. (2001). *The validity of formative assessments*. Paper presented to the British Educational Research Association Annual Conference, University of Leeds.

Davis, B. (1997). Listening for differences: An evolving conception of Mathematics teaching. *Journal for Research in Mathematics Education, 28*(3), 355 – 376.

Deci, E. L. (1992). The relation of interest to the motivation of behavior. In K. A. Renninger, S. Hidi & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 43 – 71). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum.

Deci, E. L., & Ryan, R. M. (1987a). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum.

Deci, E. L., & Ryan, R. M. (1987b). The support of autonomy and the control of behavior. *Journal of Personality and Social Psychology*, *53*, 1024-1037.

Deci, E. L., & Ryan, R. M. (1990). A motivational approach to self: Integration in personality. In D. Dienstbier (Ed.), *Nebraska symposium on motivation* (pp. 237-288). Lincoln, NE: University of Nebraska Press.

Dewey, J. (1910). *How we think.* Boston: D.C. Heath & Co.

Dewey, J. (1928). *Progressive education and the Science of education.* Paper presented at the eighth annual conference of the Progressive Education Association, Washington, DC.

Dihoff, R. E. M., Brosvic, G., Epstein, M. L., & Morgan, M. J. (2004). Provision of feedback during preparation for academic testing: Learning is enhanced by immediate but not delayed feedback. *Psychological Record*, 54(2), 207-231.

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher*, *23*(7), 5-12.

Duschl, R. A. (2003). Assessment of scientific inquiry. In J. M. Atkin & J. Coffey (Eds.), *Everyday Assessment in the Science Classroom* (pp. 41-59). Arlington, VA: NSTA Press.

Duschl, R. A., & Gitomer, D. H. (1997). Strategies and challenges to changing the focus of assessment and instruction in Science classrooms. *Educational Assessment, 4*(1), 37-73.

Dweck, C. (1999). *Self-theories: Their role in motivation, personality and development.* Philadelphia, PA: Psychology Press

Elawar, M. C., & Corno, L. (1985). A factorial experiment in teachers' written feedback on student homework: Changing behavior a little rather than a lot. *Journal of Educational Psychology, 77*(2), 162-173

Fuchs, L. S., & Fuchs, D. (1986). Effects of systematic formative evaluation – a meta-analysis. *Exceptional Children, 53*(3), 199-208.

Furtak, E. M, & Ruiz-Primo, M.A. (2005, January). Questioning cycle: Making students' thinking explicit during scientific inquiry. *Science Scope*, p. 22-25.

Furtak, E. M. (2006). *Formative assessment in K-8 science education: A conceptual review.* Commissioned paper for the Committee on Science Learning, Kindergarten through Eighth Grade, National Research Council.

Gaynor, P. (1981). The effect of feedback delay on retention of computer-based mathematical

material. *Journal of Computer-Based Instruction, 8*(2), 28-34.

Gipps, C. (1999). Socio-cultural aspects of assessment. *Review of Research in Education, 24*, 355-392.

Glasson, G. E. (1989, February). The effects of hands-on and teacher demonstration laboratory methods on Science achievement in relation to reasoning ability and prior knowledge. *Journal of Research in Science Teaching, 26*(2), 121-131.

Goodenough, H. (1957). *Cultural anthropology and linguistics*. In P. L. Garvin (Ed.), *Report of the Seventh Annual Round Table Meeting on Linguistics and Language Study* (pp. 167-173). Washington, DC: Georgetown University.

Goos, M. (2004). Learning Mathematics in a classroom community of inquiry. *Journal for Research in Mathematics Education, 35*(4), 258-291.

Goos, M. (2005). A sociocultural analysis of learning to teach. In H. Chick & J. Vincent (Eds.), *Proceedings of the 29th conference of the International Group for the Psychology of Mathematics Education, 3* (pp. 49-56). Melbourne: PME.

Goos, M. (2008). Sociocultural perspectives on learning to teach mathematics. In B. Jaworski & T. Wood (Eds.), *International handbook of Mathematics teacher education Volume 4 The Mathematics teacher as a developing professional* (pp. 75-91). Rotterdam: Sense.

Hajcak, G., Moser, J., Holroyd, C., & Simons, R. (2005). The feedback-related negativity reflects the binary evaluation of good versus bad outcomes. *Biological Psychology, 71*, 148-154

Harlen, W., & James, M. (1997). Assessment and learning: Differences and relationships between formative and summative assessment. *Assessment in Education: Principles, Policy and Practice, 4*(3), 365-379.

Harlen, W., & Deakin Crick, R. (2002). *A systematic review of the impact of summative assessment and tests on students' motivation for learning.* London: EPPI-Centre, Social Science Research Unit, Institute of Education.

Haneda, M. (1999). Modes of student participation in an elementary school Science classroom: From talking to writing. *Linguistics and Education, 10*(4), 459-485.

Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement.* London: Routledge.

Hattie, J. A. (1987) Identifying the salient facets of a model of student learning: A synthesis and meta-analysis, *International Journal of Educational Research, 11*, 187-212.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81-112.

Hoffman, M. L. (1987). The contribution of empathy to justice and moral judgment. In N. Eisenberg & J. Strayer (Eds.), *Empathy and its development* (pp. 47-80). New York, NY: Cambridge University Press.

Hoffman, M. L. (1990). Empathy and justice motivation. *Motivation and Emotion, 4*, 151-172.

Hogan, K., Nastasi, B. K., & Pressley, M. (2000). Discourse patterns and collaborative scientific reasoning in peer and teacher guided discussions. *Cognition and Instruction, 17*(4), 379 – 432.

James, M. (1992). *Assessment for learning.* Paper presented at the annual conference of the Association for Supervision and Curriculum Development, New Orleans, LA.

Kluger, A. N., & DeNisi, A. (1996). The effects of feedback interventions on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory. *Psychological Bulletin, 119*(2), 254-284.

Kohn, A. (1993). *Punished by rewards.* Boston: Houghton Mifflin.

Kulhavy, R. W. (1977). Feedback in written instruction. *Review of Educational Research, 47,* 211-232.

Kulhavy, R. W., & Anderson, R. C. (1972). Delay-retention effect with multiple-choice tests. *Journal of Educational Psychology, 63,* 505-512.

Kulhavy, R. W., Yekovich, F. R., & Dyer, J. W. (1976). Feedback and response confidence. *Journal of Educational Psychology, 68*(5), 522-528.

Kulhavy, R. W. & Wager, W. (1993). Feedback in programmed instruction: Historical context and implications for practice. In J. V. Dempsey & G. C. Sales (Eds.), *Interactive instruction and feedback* (pp. 3-20). Eaglewood Cliffs, NJ: Educational Technology Publications.

Kulik, J. A., & Kulik, C. L.(1988). Timing of feedback and verbal learning. *Review of Educational Research, 58,* 79-97.

Lee, V. E., Chen, X., & Smerdon, B. A. (1996). *The influence of school climate on gender differences in the achievement and engagement of young adolescents.* Washington, DC: American Association of University Women.

Li, M., Shavelson, R. J., Kupermintz, H., & Ruiz-Primo, M. A. (2002). On the relationship between Mathematics and Science achievement: An exploration of the third international Mathematics and Science study. In D. F. Robitaille & A. E. Beaton (Eds.), *Secondary analysis of the TIMSS data* (pp. 233-249). Boston, MA: Kluwer Academic Publishers.

Locke, E. A., Cartledge, N., & Koeppel, J. (1968). Motivational effects of knowledge of results: A goal-setting phenomenon. *Psychological Bulletin, 70*(6), 474-485.

Mory, E. H. (2003). Feedback research revisited. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (2nd ed., pp. 745-783). Mahwah, NJ: Lawrence Erlbaum.

Mory, E. H. (2004). Feedback research revisited. In D. H. Jonassen (Ed.), *Handbook of research on educational communications and technology* (2nd *ed*., pp. 745-783). Mahwah, NJ: Lawrence Erlbaum.

Mory, E. H. (1994). Adaptive Feedback in computer-based instruction: Effects of response certitude on performance, feedback-study time, and efficiency. *Journal of Educational Computing Research, 11*(3), 263-290.

Mutch, A. (2003). Exploring the practice of feedback to students. *Active Learning in Higher Education, 4*(1), 24-38.

Natriello, G. (1987). The impact of evaluation processes on students. *Educational Psychologist, 22*(2), 155-175.

Newman, R. S., & Schwager, M. T. (1993). Students' perceptions of the teacher and classmates in relation to reported help seeking in math class. *The Elementary School Journal, 94*(1), 3-17.

Oldfather, P., & Dahl, K. (1994). Toward a social constructivist reconceptualization of intrinsic motivation for literacy learning. *Journal of Reading Behavior, 26*, 139-158.

Oldfather, P., & McLaughin, J. (1993). Gaining and losing voice: A longitudinal study of students' continuing impulse to learn across elementary and middle level contexts. *Research in Middle Level Education, 17*, 1-25.

Oldfather, P., & Thomas, S. (1996). *"The changer and the changed": Student-initiated research on literacy motivation and schooling* (Reading Research Rep. No. 61). Athens, GA: National Reading Research Center.

Palinscar, A. S. (1998) Social constructivist perspectives on teaching and learning, *Annual Reviewof Psychology, 49*, 345–375.

Piaget, J. (1970). *Genetic epistemology.* New York, NY: W. W. Norton and Company.

Pintrich, P. R. (1995). *Understanding self-regulated learning.* San Francisco, CA: Jossey-Bass.

Pintrich, P. R., & Zusho, A. (2002) Student motivation and self-regulated learning in the college Classroom. In: J. C. Smart & W.G. Tierney (Eds.), *Higher education: Handbook of theory and research* (Vol. XVII), New York, NY: Agathon Press.

Pressey, S. L. (1926). A simple device which gives tests and scores and teaches. *School and Society, 23*, 373-376.

Pressey, S. L. (1950). Development and appraisal of devices providing immediate automatic scoring of objective tests and concomitant self-instruction. *The Journal of Psychology, 29*, 417-447.

Ramaprasad, A. (1983). On the definition of feedback. *Behavioural Science, 28*, 21-38.

Rodgers, C. (2006). Attending to student voice: The impact of descriptive feedback on learning and teaching. *Curriculum Inquiry, 36*(2), 209-237.

Ruiz-Primo, M. A., & Li, M. (2002). *Vignettes as an alternative teacher evaluation instrument: A pilot study*. Paper presented at the AERA Annual Meeting, New Orleans, LA.

Ruiz-Primo, M. A., Li, M., Ayala, C. C., & Shavelson, R. J. (2004). Evaluating students' Science notebooks as an assessment tool. *International Journal of Science Education, 8*(26), 1477-1506.

Ruiz-Primo, M. A., Shavelson, R. J., Li, M., & Schultz, S. E. (2001). On the cognitive validity of interpretations of scores from alternative concept-mapping techniques. *Educational Assessment, 7*(2), 99-141.

Ryan, R. M., & Deci, E. L. (2000) Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*, 54-67.

Sadler, D. R. (1983). Evaluation and the Improvement of Academic Learning. *Journal of*

Higher Education, 54(1), 60-79.

Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science, 18,* 119-144.

Sadler, D. R. (1998). Formative assessment: Revisiting the territory. *Assessment in Education: Principles, Policy, and Practice, 5*(1), 77-84.

Savant, C. J. (1958). *Basic feedback control system design.* New York, NY: McGraw Hill.

Schwartz, D. L., & Bransford, J. D. (1998). A time for telling. *Cognition and Instruction, 16*(4), 475-522.

Scriven, M. (1967). The methodology of evaluation. In R. W. Tyler, R. M. Gagné & M. Scriven (Eds.), *Perspectives of curriculum evaluation* (Vol. 1, pp. 39-83). Chicago: RAND.

Shuell, T. J. (1980). Learning theory, instructional theory, and adaptation. In R. E. Snow, P. A. Frederico & W. E. Montague (Eds.), *Aptitude, learning, and instruction Volume 2 Cognitive process analyses of learning and problem-solving* (pp. 277-302). Hillsdale, NJ: Lawrence Erlbaum.

Schunk, D. H. (1991). Self-efficacy and academic motivation. *Educational Psychologist, 26,* 207-231.

Schunk, D. H., & Swartz, C. W. (1993). Goals and progressive feedback: Effects on self-efficacy and writing achievement. *Contemporary Educational Psychology, 18,* 337-354.

Sfard, A., & Kieran, C. (2001) Cognition as communication: Rethinking learning-by-talking through multi-faceted analysis of students' mathematical interactions. *Mind, Culture, and Activity, 8*(1), 42-76.

Shute, V. (2008). Focus on formative feedback. *Review of Educational Research, 78*(1), 153-189.

Skinner, B. F. (1954). The science of learning and the art of teaching. *Harvard Educational Review, 24*, 86-97.

Skinner, B. F. (1968). *The technology of teaching.* New York, NY: Meredith Corporation.

Slavin, R. E. (1995). *Cooperative Learning: Theory, research and practice*. Boston, MA: Allyn & Bacon.

Solano-Flores, G., & Li, M. (in press). *Examining the dependability of performance measures for English-language learners*. A chapter to be published by Lawrence Erlbaum.

Stiggins, R. J. (2001). *Student-involved classroom assessment* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Stiggins, R. J. (2002). Assessment crisis: The absence of assessment FOR learning. *Phi Delta Kappan, 83*(10), 758-765.

Stiggins, R. J. (2005). From formative assessment to assessment FOR learning: A path to success in standards-based schools. *Phi Delta Kappan, 87*(4), 324-328.

Stiggins, R. J., & Conklin, N. F. (1992*). In teachers' hands: Investigating the practice of classroom assessment.* Albany, New York, NY: State University of New York Press.

Taras, M. (2001). The use of tutor feedback and student self-assessment in summative assessment tasks; Towards transparency for students and tutors, *Assessment and Evaluation in Higher Education, 26*(6), 605–614.

Taras, M. (2002). Using assessment for learning and learning from assessment, *Assessment and Evaluation in Higher Education, 27*(6), 501-510.

Taras, M. (2003). To feedback or not to feedback in student self-assessment. *Assessment and Evaluation in Higher Education, 28*(5), 549-565.

Thomas, S., & Oldfather, P. (1997). Intrinsic motivations, literacy, and assessment practices: "That's My Grade. That's Me." *Educational Psychologist, 32*(2), 107-123

Thorndike, E. L. (1913*). Educational psychology volume 1: The original nature of man.* New York, NY: Teachers College Columbia University.

Torrance, H., & Pryor, J. (2001). Developing formative assessment in the classroom: Using action research to explore and modify theory. *British Educational Research Journal, 27*(5), 615-631.

Tunstall, P., & Gipps, C. (1996). Teacher feedback to young children in formative assessment: A typology. *British Educational Research Journal, 22*, 389-404.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge,

MA: Harvard University Press.

Vygotsky, L. S. (1987/1934). Thinking and speech (N. Minick, Trans.). In R. W. Rieber & A. S. Carton (Eds.), *The Collected Works of L. S. Vygotsky* (Vol. 1). New York, NY: Plenum Press.

White, B., & Frederiksen, J. (1998). Inquiry, modeling, and metacognition: Making Science accessible to all students. *Cognition and Instruction, 16*(1), 3-118.

White, B., & Frederiksen, J. (2005). A theoretical framework and approach for fostering metacognitive development. *Educational Psychologist, 40*(4), 211-223.

Wiggins, G. (1993). *Assessing student performance: Exploring the purpose and limits of testing.* San Francisco, CA: Jossey-Bass.

Wiliam, D. (2006). Assessment: Learning communities can use it to engineer a bridge connecting teaching and learning. *Journal of Staff Development, 27*(1), 16-20.

Wiliam, D. (2007). Changing classroom practice. *Educational Leadership, 65*(4), 36-42.

Wiliam, D. (2011). *Embedded Formative Assessment.* Bloomington, IN: Solution Tree Press.

Wiliam, D., & Black, P. (1996). Meanings and consequences: A basis for distinguishing formative and summative functions of assessment? *British Educational Research Journal, 22*(5), 537-548.

Winne, P. H. (1996). A metacognitive view of individual differences in self-regulated learning. *Learning and Individual Differences, 8*, 327-353.

Winne, P. H., & Butler, D. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research, 65*(3), 245-274.

Wittrock, M. C. (1982). *Educational implications of recent research on learning and memory*. Paper presented at the annual meeting of the American Educational Research Association, New York, NY.

Yeany, R. H., & Miller, P. A. (1983). Effects of diagnostic/remedial instruction on Science learning: A meta-analysis. *Journal of Research in Science Teaching*, *20,* 19-26.