INQUIRY IN THE CLASSROOM

An Action Research Report

by

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Introduction

When teachers reflect upon their choice of vocation, often times it comes to mind that the reason they teach is because they remember the true joy and delight in the discovery of knowledge. Mastering content and understanding became not only a goal but also the most rewarding part of school. How excitedly motivated they were! How their achievement built their self-confidence as students and as future adults! These powerful memories of motivation and self-confidence still stir and have informed the conviction of why many teachers presently teach.

However, the challenge for instructors in the public schools is to impart the feeling of this recalled pleasurable activity to the students of today so they too can become invested students and lifelong learners. Many teaching methods have been tried and tested with varying degrees of success. Among the most promising contemporary pedagogical techniques to increase student motivation and self-confidence is that of inquiry, or classroom questioning. The practice of inquiry uses interrogative sentences in succession at a difficulty level just beyond the students' current level of achievement. For optimum student engagement, higher and lower order questions are purposefully selected and mixed as predicated by the curriculum content while simultaneously the necessary wait- and think-times dictate the flow of questions.

General research (Cotton, 2001) has embraced the following tenets of inquiry:

- Instruction which includes positing questions during lessons is more effective in producing achievement gains.
- Students perform better on test items previously asked as recitation questions than on information they have not seen previously.

- Oral questions posed during classroom recitations are more effective in fostering learning than written questions.
- Questions that focus student attention on important elements in the lesson lead to improved comprehension than questions that do not.

The goal of increased motivation and self-confidence for my students has been set. The pedagogical gauntlet has been thrown down. Through the practice of classroom questioning, I hope to see a group of students in a special education class move from conflicted learners to invested, confident young achievers.

My current, not atypical, self-contained classroom situation is encapsulated as follows. At the start of this year the multi-grade high school math class is comprised of a group of seven boys and five girls on Individual Education Plans. They come into class mostly rested and adequately fed. Four of the students require one-to-one aides for physical and/or social-emotional issues. Once the seating arrangement has been fine-tuned, personalities, multiple intelligences strengths and weaknesses, as well as academic and social-emotional needs begin to become evident; for, it is the establishment of a community of learners within the seating plan that begins to define these math students. Certain students thrive in the front row of U-arranged desks. Others are more comfortable at a lab table towards the back. And still others are generous enough to feel comfortable in the middle. For various reasons one student will work on a higher level when seated near another student. Peer-tutoring and interpersonal learning is at its infancy, but the seeds of development are present. A few students require higher level pre-algebra lessons, but mostly the students are on the same academic level with the same amount of prior knowledge.

The disabilities in this math group range from autism, pervasive developmental disorder, high anxiety, and extreme sound sensitivity to cerebral palsy, specific learning disability, and attention deficit/hyper-active disorder. The strengths evident within this company of students include abstract thinking, natural math intelligence, tentative engagement, positive attitude, and a willingness to learn.

Initially, many of the students try to remain under the radar--silent, shrugging, perhaps slightly argumentative. Some have trouble remaining focused and are easily brought into off-track conversations. The para-professionals can also be problematic, talking amongst themselves in murmurs about non-school topics.

There is no sense of community, no team mentality, little individual motivation, minuscule self-confidence, and less-than optimum autonomy. A mostly disenfranchised group are they, even though it must be said that this is quite typical for the beginning of the school year. Both the ninth- and tenth-graders are new to the school.

Therefore, the following research seeks to explore questioning's function in teaching and learning and asks "Will the frequent integration of classroom questioning strategies positively influence special education students' motivation and self-confidence in the self-contained math setting?" This research design, a case study of special education students within a self-contained multi-grade math class at Lynn Classical High School, in the city of Lynn, Massachusetts, measured, both quantitatively and qualitatively, the changes in student motivation and self-confidence following sixteen weeks of inquiry sessions.

Baseline data regarding the implementation of inquiry as well as the current levels of student motivation and self-confidence and their openness and awareness of classroom questioning were collected in the form of participant observer field notes and the description of the Coalition of Essential Schools *Chalk Talk* in which the students silently scribed their answer (s) to the question, "How do you feel about mathematics?" Paper questionnaires on the role of questioning in the classroom were explained and independently answered by the math students, while the participant observer later synthesized and analyzed the compilation of ratings. The students were asked to rate the learning, literacy, educational, and cultural implication of classroom questioning through a scale of one to four. The ranking of *one* reflected a strong disagreement with the statement as noted by a two thumbs down while the number *four* strongly agreed with the statement as noted by two thumbs up. The questionnaire was read to the students and the rating system was reviewed periodically.

Classroom questioning sessions occurred multiple times per week while formative assessments by this participant observer as well as the students were conducted weekly to inform future action taken during this action research time frame. Exit questionnaires for the students were compiled with the field notes and interviews to measure possible growth in student self-confidence and motivation through the practice of inquiry, or classroom questioning.

This research hoped to inform the scant literature available on the positive effect of the expert practice of inquiry on special education students' motivation and self-confidence within a self-contained mathematics setting.

Chapter I - Rationale

In 1983, the federally sponsored National Commission on Excellence in Education issued *A Nation at Risk*. It found a national educational crisis afoot. Our schools, the report stated, held the illiterate, tolerated low-level performance, showed a decline in test scores in certain subjects, fared poorly when examination scores were compared to students in other countries, and lacked equity. Educational reform was born.

Schools were asked to improve, innovate, and restructure. Within this revamping of roles, expectations, and relationships, the most ambitious goal—that of student achievement---required students to display complex problem solving, inferential understanding, and high-level communication skills. Standards for high-quality pedagogy and assessments along with authentic student achievement were applied to a myriad of pedagogical techniques and curriculum standards. The success rate has been decidedly mixed.

Mandated rigorous content standards, informed teaching skills, and the deep desire to see students demonstrate, articulate, and achieve should bring about student achievement. Students should achieve authentically when all good pedagogy standards are in place and yet they often times have lost the will to learn, have forgotten how it feels to be motivated, and/or have a malaise that is deeply ingrained and undercuts their self-confidence daily.

As a high school special educator I see firsthand that some missing element needs to be explored and placed into the achievement equation. It is from this vantage point I have approached inquiry in the classroom. I have observed that classroom questioning can engage a student, propel him to take a small step towards success, and ultimately open up to new experiences in learning. Inquiry is not a magic pill, but coupled with other pedagogical techniques and the establishment of a respectful relationship of community between student and teacher, classroom questioning can perhaps provide a breakthrough in student learning that we teachers truly desire and require.

An analysis of the current classroom where special education students were lacking in motivation and self-confidence as learners revealed patterns and trends, systemic structures, and mental models. All were firmly entrenched, often denied or forgotten, or hidden from view in the subconscious.

The general acceptance of special education students as insufficiently motivated or less than self-confident as a whole followed patterns and trends felt school-wide. A symbiotic norm found a portion of the students themselves accepting this pattern and constantly creating a renewed self-fulfilling prophecy of behaviorally impacted classroom actions and manners. Therefore, more and more special education students remained unmotivated and without academic self-confidence. Overall, educators and administrators lacked the resolve to implement the professional development in effective pedagogy required to remedy this trend.

Systemic structures fed the patterns and trends. Segregated by subject matter, special education students remained apart from their peers in their content area classes. They did not have access to an inclusive classroom setting with the support of a learning center like other inclusion models in the city. However, within their transitional learning classes, the students did move between three teachers for math, science, and social studies while remaining with their main teacher for English language arts and vocational/life skills training.

Lack of proper sustained educational supports for the academic achievement of special education students, often due to cost-cutting measures which raised class sizes or down-sized services, maintained the status quo. Eleven to fourteen students make up each of the three current transitional learning classes. However, money was found to support business-model spending on costly consultants whose success was often questionable. Inadequate professional development, often by outside authorities rather than the teacher-experts within, led to once or twice a year professional development days which found little added pedagogical knowledge or techniques and little collegiality. Academic achievement measured through high-stakes testing as the anointed assessment method remained dogmatically in place by the state of Massachusetts. And most importantly, universal preschool was not provided to all students to give them that all-too-important step-up so needed for the building of self-confidence and motivation and the achievement of success over a lifetime.

Pushing up from the deep of this iceberg were unyielding mental models. Heard, off-the-record, among special and regular education teachers: "We try every pedagogical fad and there is no increase in motivation and/or self-confidence." "I do not expect professional development's pedagogical techniques to be innovative and successful."   "We must jump through every hoop devised by the DESE (Department of Elementary and Secondary Education) and NCLB (No Child Left Behind) so that our students can score well on high-stakes tests, but fail to realize without motivation and self-confidence, special education students will not achieve their optimal academic performance in the classroom nor on the mandated state tests." "Every year special education students come into their classes more and more disaffected, disenfranchised, and behavioral. It's demoralizing and sometimes I feel that nothing can stop this downward spiral as the American family continues to break down."

As a result this urban high school has been actively redesigning its transitional learning classrooms in a move away from self-contained all-subject-matter classes to partial inclusion with the students of these three settings moving between classes and floors to go to math, science, and social studies taught by different teachers. Within this actively restructuring environment I place my action research on inquiry, or classroom questioning. As the culture at the school changes, I hope my findings can help pave the way towards a more inclusive, creative, and student-oriented, indeed differentiated, pedagogical technique for all of our transitional learning special education teachers.

Differentiated instruction states that a child's optimal achievement can only be achieved by first assessing his prior knowledge. Using this unique starting point, the teacher then addresses each student's specific learning strengths and weaknesses. The activity of differentiated instruction embraces such pedagogical techniques as Dr. Howard Gardner's theory of multiple intelligences, noted differences in processing skills, the insertion of wait- and think-times, and the implementation of classroom questioning or inquiry/constructivism. The theory of differentiation asks teachers to focus on the individual student and not wholly on the subject matter. Instead teachers are to integrate the content with each student's skills independently and intimately through the understanding of every student's needs and interests. The teacher who practices differentiated instruction believes that everyone learns differently, quality of information trumps how much is learned, and that "one-size-fits-all" curriculum is outdated and obsolete. Formative assessments help to formulate the pace and complexity of the class. Such ongoing assessments, which include precise and logical rubrics, empower both the students and the teacher for everyone knows where they are going and how they are going to get there. By its very nature, the philosophy of differentiated instruction is inclusive and equitable allowing each student appropriate access to the learning process and the curriculum. Inquiry, or classroom questioning, is an example of the intentional teaching that allows for differentiated and equitable instruction that can increase motivation and self-confidence in the academic arena.

Even before I became aware of the philosophy of differentiated instruction, I have been enamored of the teaching strategy known as inquiry. I have observed an increase in student autonomy through my use of sustained questioning. I understand how classroom participation enables a student to feel academic success. I also realize that a student's act of listening and vocalizing increases memory retention and thus is another avenue to academic fulfillment. Students are afforded sufficient wait- and think-times and all answers are positively acknowledged. Even when a response is not one hundred percent correct, that germ of the right answer is acknowledged, reworded as another question, and asked again. The success that students feel, often for the first time in a very long time, demonstrates to me the validity of inquiry in the classroom to promote motivation and self-confidence.

The indicators of such success, as found in the motivated and self-confident student, follow. This child is a curious, academic risk-taker who persistently seeks math solutions while able to appreciate and tolerate the unknown factor in math problems. A willingness to partake in inquiry or classroom questioning, as well as to ask and write questions, equally defines the motivated and self-confident learner. This student can also actively construct his or her own math knowledge while also perhaps taking interest in peer-tutoring. The self-confident and motivated pupil may also display characteristics of the developing life-long learner.

Throughout my career as a special education teacher, I have practiced inquiry. Four years ago in a special education classroom for the cognitively delayed and behavioral, I saw glimmers of smiles brought about by academic success and looks of awe when the students felt the glow of teacher and peer acceptance. Five years ago, in a fifth-grade resource room, I observed eager hands shoot up to answer sustained, repeated questions. The final culmination of a unit on magnetic properties that answered the essential question-- *How can magnetic force be proven when it is an invisible force?*-- led to a successful independent final oral project presentation of the unit findings. And last year in an eleventh grade introduction to algebra II class, I witnessed a student forgetting his troubles and finding anew the amazement felt from a deeper understanding of math concepts. When students become accustomed to repeated inquiry often in chunks of three to five questions, they begin to find anew the delight in learning which they have forgotten or perhaps never knew. Academic success, brought about by many factors of which classroom questioning is one, allows students to risk wrong answers, to post questions that may appear misguided, and to buck the peer pressure that tries to maintain the lower-level classroom status quo.

In the summers of 2007 and 2008, I mentored select high school students from Boston, Lynn, and Lawrence, Massachusetts, in authentic x-ray astronomy research in the Chandra Astrophysics Institute (CAI) at the Massachusetts Institute of Technology. Through rigorous inquiry and constructivism, the students explored physics, astrophysics, and data analysis tools. For example, they were required to construct various laws of motion from the questions posited by the instructors and the basic materials provided. Self-confidence and motivation increased as the students found scientific success. Their increased autonomy showed itself in their motivated self-learning and active seeking of new knowledge. CAI's pre- and post-testing, questionnaires, written reflections, research presentations, surveys, and faculty observations found that the inquiry/constructivist method of imparting knowledge and understanding was valid. Overall, participants noted in questionnaires and through journaling that the inquiry/constructivist approach to learning and connection between math and science was valuable and applicable to their future studies.

Current peer-reviewed research on classroom questioning and its corresponding scaffolds of wait- and think-times along with critical thinking on educational reform have mostly suggested that effectively delivered inquiry is a valid pedagogical technique which can lead to authentic classroom achievement and concurrently serve to motivate and increase self-confidence. Cotton's (2001) meta-analysis on classroom questioning provides the basis for the best-practices element of the research. Although research has linked classroom questioning and authentic student achievement, there is a paucity of research on the definitive link between inquiry and motivation and self-confidence in special education students. However, most resembling my research goal is Savich's (2008) data that support students' "engagement, enthusiasm, participation, and interest" were increased through the use of interactive or inquiry-based instruction within the social studies classroom. Conversely, Dillon's (1981) dissenting voice stated that classroom questioning is not only threatening but also counter-productive. Barring Dillon, current research and best practices indicates that my action research can support existing studies, influence current systems and mental models, as well as support the continuance of the inclusionary model within multiple self-contained classrooms.

Chapter II - Literature Review

Inquiry began with the Greek philosopher, Socrates (ca. 470-399 BC). His approach to teaching was based on the rigorous practice of disciplined, thought-provoking, and engaging dialogue which could help students learn to construct their own knowledge and ultimately determine the validity of their ideas and conclusions. Centuries later, in *Logic - The Theory of Inquiry*, Dewey (1938) expounded upon the epistemology of inquiry and the need to not accept blindly but to question given "facts" so that information could be analyzed, synthesized, and evaluated.

> All competent and authentic inquiry demands that out of the complex welter of existential and potentially observable and recordable material, certain material be selected and weighed as data of the 'facts of the case.' This process is one adjudgment, of appraisal or evaluation. On the other end, there is, as has been just stated, no evaluation when ends are taken to be already given. (p. 497)

Elkind (2004), in his essay entitled "The Problem with Constructivism," addressed the history of constructivism, in "all of its various incarnations." When he referred to the epistemological term's historical antecedents he was including questioning under the umbrella of constructivism.

> Constructivism thus echoes the philosophy implicit in Rousseau's Emile (1962) in which he argues that children have their own ways of knowing and that these have to be valued and respected. It also reflects the Kantian (Kant 2002) resolution of the nature/nurture controversy. Kant argued that the mind provides the categories of knowing, while experience provides the content. Piaget (1950) created the

> contemporary version of constructivism by demonstrating that the categories of knowing, no less than the contents of knowledge, are constructed in the course of development. Vygotsky (1978) added the importance of social context to the constructivist epistemology—a theory of knowledge and knowledge acquisition. (p. 50)

Elkind (2004) continued to state that bringing the epistemology of constructivism (and the scaffold of inquiry) into the classroom was motivated by "genuine pedagogical concerns" and not by "political events (curriculum reform movement spurred by the Russian launching of the Sputnik), social events (such as the school reforms initiated by the Civil Rights Movement), or by a political agenda (e.g., A Nation at Risk; the No Child Left Behind initiative)" (p. 50).

Today many educators have used inquiry, or what is more commonly called classroom questioning, in their practice. Inquiry was specifically addressed in the *Massachusetts Science and Technology/Engineering Curriculum Framework* (2006):

> Engaging students in inquiry-based instruction is one way of developing conceptual understanding, content knowledge, and scientific skills. Inquiry, experimentation, and design should not be taught or tested as separate, stand-alone skills. Rather, opportunities for inquiry, experimentation, and design should arise within a well-planned curriculum. Doing so will make clear to students that what is known does not stand separate from how it is known. Asking questions and pursuing answers are keys to learning in all academic disciplines. (p. 9)

However, what is inquiry or classroom questioning? According to Cotton's (2001) meta-analysis, "Classroom Questioning," a question was any interrogative sentence while classroom questioning, as a current teaching method utilized to promote active student participation and metacognition, was defined as "instructional cues or stimuli that convey to students the content elements to be learned and directions for what they are to do and how they are to do it" (p. 1).

But had peer-reviewed research been able to connect inquiry to student motivation and self-confidence and ultimately to student autonomy? Renchler (1992) in "Student Motivation, School Culture, and Academic Achievement: What School Leaders Can Do" defined student motivation and self-concept as "the way a person responds to a task and his or her decision to invest the time and energy necessary to succeed in accomplishing it which is dependent upon a complex blend of present thoughts and previous experiences" (p. 15). A sense of self-confidence, according to Renchler and confirmed by the researchers Atkinson and Feather (1966) and Vroom (1964), was "a critical variable in achieving success and in becoming motivated to attempt certain tasks. Individuals develop preconceived notions about their chances for success or failure based upon their level of self-confidence" (p. 15). The ultimate sense of autonomy or self-determination, developed once ownership or control over school situations was felt, motivated students to act (p. 15). According to Bruce (1995) in "Practicing What We Preach: Creating the Conditions for Student Autonomy," autonomy required a "pursuit of freedom from the constraints of prevailing concepts of learning and knowledge, of academics as guardians and purveyors of that knowledge, and of students as its passive recipients" (p. 74).

Findings from research on inquiry included Bond's (2007) assertion that twelve questioning strategies increase the success of classroom recitations and by extension translate to successful learning. With academic success, Bond concluded, comes self-confidence and motivation. However, at times inquiry was not as successful as the research literature promoted because “students may misbehave if they are unclear about the expected behavior. Exchanges between teachers and students occur quickly during a question-and-answer session, and teachers seldom make explicit the way they want the class to respond. Thus, students act out because they are unable to ‘read the teacher’s mind’” (p. 19). Successful classroom recitations were assured when certain strategies were in place. Questions needed to be pre-planned. Students were required to be cued and asked appropriately leveled questions that would evoke correct responses. Teachers needed to call on all students, varying who responded and evaluating how and why they responded. After providing adequate wait-time, teachers reacted to every answer, corrected errors, and asked followup questions. Besides encouraging students to respond, teachers established the expectations of inquiry within the classroom (pp. 19-21).

Cotton (2001) concurred. She stated that “the high incidence of questioning as a teaching strategy, and its consequent potential for influencing student learning, have led many investigators to examine relationships between questioning methods and student achievement and behavior.” Her findings have noted that for older students higher cognitive questions (“open-ended, interpretive, evaluative, inquiry, inferential, and synthesis queries”) which asked the student to analyze, synthesize, and evaluate in order to create an answer or to support an answer with logically reasoned, inferential evidence, employed fifty per cent of the time or more, led to increases in motivated, focused attention; the length and relevance of responses; the use of complete sentences and pertinent questions; the number of student-to-student interactions; and inferential, expository thinking (p. 6).

Although the above outcomes could influence authentic student academic achievement, many of these outcomes might by extension also contribute to student investment, motivation, self-confidence, and autonomy. However, Cotton (2001) noted that definitive research had been lacking on the use of higher cognitive questions for all age groups:

> Quite a number of research studies have found higher cognitive questions superior to lower ones, many have found the opposite, and still others have found no difference. The same is true of research examining the relationship between the cognitive level of teachers' questions and the cognitive level of students' responses. The conventional wisdom that says, "ask a higher level question, get a higher level answer," does not seem to hold. (p.5)

Cotton (2001) also had noted that reports by educational researchers on the positive linkage between the epistemology of inquiry and student attitudes was indirectly evident but that concrete research on the connection was "virtually nonexistent" (p. 9).

In April of 2008 Savich asked, "How do I motivate students to change their negative attitudes and apathy about history?" He found through the comparison of the pedagogical techniques of inquiry and direct instruction that in the use of classroom questioning not only were critical thinking skills improved but also that students exhibited a change in classroom behavior from "apathy and boredom" to "enthusiasm and engagement for history" (p. 13). He noted that inquiry was mandated in the *U.S. National History Standards* (1994) *Goals* (2000.) In an assigned student research project he found "that the levels of student engagement, enthusiasm, participation, and interest were radically increased. There was a concomitant large improvement in critical thinking skills because students were able to personally relate to the issues and to have a deeper understanding of the underlying issues and problems involved" (p. 17). He measured student involvement, independent learning, and creativity through self-created rubrics and examined students' attitudes regarding abstract inferential thinking through questionnaires. "The results demonstrated that an overwhelming majority of the students in the interactive format class preferred that method of instruction (inquiry) over the lecture format (direct instruction)" and that based on quantitative results "the interactive (inquiry) teaching method resulted in the highest test scores." However, Savich (2008) did question the validity of his results due to the "Hawthorne effect." This "conscious knowledge on the part of participants that they are receiving 'special' attention, may have skewed the results in a more positive direction, resulting in inflated results" (p. 23). Ultimately Savich found that inquiry increases test scores and active student learning.

Likewise Collier, Guenther, and Veerman (2002) remarked in *Developing Critical Thinking Skills Through a Variety of Instructional Strategies* that sustained classroom questioning, brought about by "practice, practice, and practice," led to student confidence "to venture an answer. The answers were not always plausible, but good discussion and reasoning developed" (p. 63).

In 1972 Rowe invented the pedagogical scaffolding technique of wait-time. She noted that when teachers practiced inquiry at too brisk a pace, students did not have enough time to think. Following ten years of research, the proper amount of silence needed for students to process answers following classroom questioning was deemed critical and measurable. In "Payoff from Pausing," Rowe (1995) recommended that average wait-times be three seconds at a minimum. If the teacher changed his or her questioning recitations to include ample wait-time then the following could happen. The length of student responses increased. Students independently responded with increased appropriate answers and expounded upon their thoughts.

Failures to respond decreased from a high of thirty per cent to five percent. Students themselves phrased questions and hypothesized proposals while the contributions by “so-called slow learners” increased. The number of disciplinary actions by teachers decreased. However, if wait-time was paltry, student responses often were incomplete and lacking in cohesion of evidence and inference (pp. 1-2). When implemented as a part of classroom inquiry technique, the variable of proper wait-time successfully scaffolded the methodology of inquiry and aided in student self-confidence and motivation as noted in Rowe’s (1995) findings of decreased “disciplinary moves” by teachers and the increase in number of questions initiated by students and added involvement by the “so-called slow learners.”

Building on Rowe’s wait-time method, Stahl (1985) concluded that adequate think-time provided the necessary processing-time support for teachers as well as students:

> The convention is to use 3 seconds as the minimum time period because this time length represents a significant break-through (or threshold) point: after at least 3 seconds, a significant number of very positive things happen to students and teachers...The concern is to provide the period of time that will most effectively assist nearly every student to complete the cognitive tasks needed in the particular situation (p. 2).

It could be asserted that Stahl’s (1985) “very positive things” would include increases in student motivation and self-confidence.

A resounding negative voice was that of Dillon (1981). In “To Question and Not to Question During Discussion: Non-Questioning Techniques,” Dillon asserted that the practice of inquiry was not relevant in the classroom discussion unless the teacher personally was in need of information. He concluded, along with Cotton (2001) in her aforementioned meta-analysis, that higher cognitive questions did not definitively lead to higher order thinking and that the choice of either a higher or lower order question made little difference in authentic student achievement. Dillon's (1981) point was that inquiry as a pedagogical technique did not take away the stigma and stress of questioning, which was often negatively interpreted by students as an interrogation. Contrary to the former research cited, Dillon's one-hundred-and-eighty-degree turn away from many researchers' findings claimed that "not to question" and having "alternatives to questioning" were preferable to classroom questioning. He felt that when a teacher wanted a student to expound further the teacher should "invite the student by a mixed declarative-imperative (sentence)."

When "not to question" ironically included the rationale of skill sets for the practicing teacher of inquiry. Do not question "at your every or every other turn at talk." Do not question when a student pauses or asks a question. Do not ask "why" questions or use questioning to make a point or to probe further. Do not begin or end a lesson with a question. Most intriguing, do not hope to gain a student response when the thought has only occurred in the teacher's mind. And most antithetical to the classroom questioning pedagogy, do not question "in hopes of stimulating student thought and discussion"
(p. 17).

In conclusion, current research on classroom questioning and its corresponding scaffolds of wait- and think-times along with critical thinking on educational reform had mostly suggested that effectively delivered inquiry was a valid pedagogical technique which could lead to authentic classroom achievement and then concurrently serve to motivate, increase self-confidence, and by extension promote autonomy in students. Therefore, current peer-reviewed research and best practices indicated that this researcher's question could support existing studies. "Does the pedagogical technique of inquiry in the special education classroom lead to an increase in student motivation, self-confidence, and be extension autonomy?"

Chapter III - Description of Action Taken

In the fall of 2009, this action researcher sought the answer to the overarching question, could sustained inquiry in the special education mathematics classroom lead to an increase in student motivation and self-confidence? In response to this stimulating question, mathematics classroom inquiry sessions occurred multiple times per week and were recorded as dialogues and student work samples within assiduously recorded field notes. The level of authentic student achievement from these periods of sustained classroom questioning was also noted in short student-brainstormed math writes. Student attitudes and beliefs were assessed in a baseline-establishing questionnaire for the students in September and compared to the summative questionnaire given in December. Likewise, a chalk talk looked at unedited student thoughts about math. This silent, student-run activity in writing was also performed twice to look at any change in student self-confidence and motivation as they scribed their answers to the question, "How do I feel about mathematics?"

Baseline data were culled from the initial paper questionnaire. The participant/observer synthesized and analyzed the compilation of the four-leveled ratings looking for patterns within the students' attitudes regarding frequent and sustained questioning in the classroom. The students were asked to quantify the learning, literacy, educational, and cultural implications of classroom questioning through a scaled rating of one to four. The ranking of one reflected a strong disagreement with the statement as noted by two thumbs down while the number four reflected strong agreement with the statement, as noted by two thumbs up. The questionnaire was read to the students, the rating system was reviewed periodically, and examples of each concept were provided to make it easier for the students to select their responses. Ten of the eleven students were able to complete the questionnaire independently. The one-to-one paraprofessional helped the eleventh student to answer the questionnaire.

Formative assessments in the structure of two short whole-group, brainstormed math writes, as facilitated by the teacher as participant/observer, were conducted to inform future action taken during the twelve-week research time frame. The interdisciplinary, math and science Cohesion Experiment Collins write, along with the Comparative Algebra Collins write, assessed student motivation and self-confidence through the students' articulate explanations, in-depth understandings, abstract interpretations, and cohesive applications of math and science facts and predictions following multiple-day, sustained inquiry sessions. The two Collins FCAs are noted on pages 59 and 63, respectively.

Exit questionnaires, identical to the initial baseline-establishing questionnaires, and a repeat of the Chalk Talk silent protocol were answered by the students. These were compiled and compared with the field notes and student work to identify regular sequencing in growth in student self-confidence and motivation through the practice of inquiry within the special education self-contained mathematics classroom. Four charts comparing the student responses to the baseline and exit questionnaires are found on pages 67 through 71.

Specifically, the Chalk Talk allowed the students to voice their feelings and attitudes towards mathematics. As a student-run activity, each student was able to write as much or as little as suited them. The students stood in a semi-circle around pieces of butcher paper hung on the wall of the classroom. Holding individually color-coded markers to identify their specific writings, the students thought about mathematics' structures, issues, and challenges as well as their own purposes and motivation, along with their wants and needs. The two Chalk Talks, a protocol from The Coalition of Essential Schools, urged thoughtful contemplation and self-assessment. Students could respond to their classmates' postings with their own ideas, either in agreement or not.

In order to better understand the following participant-researcher field notes, the following descriptors define the student/subjects as social-emotional, physical, and academic individuals at the start of the school year 2009. These students are a part of a multiple-grade special education mathematics class.

Ryan

An eighteen-year-old young man, Ryan is empathetic, nurturing, articulate, and a wonderfully engaged senior. He is an active participant in math class who is able to answer abstract higher-level questions with in depth and thoughtful replies. Confidently gay, this senior loves to create ELA assignments which find him exploring subjects dear to him. And he loves to clean. He moves through classrooms, helping out his favorite teachers, even sweeping up a packed room filled with students serving detention. Non-plussed, he does not feel stigmatized as he sweeps underneath desks and smiles while wiping a whiteboard. When I ask him if I can pay him in school supplies for all he does for me, he says he lives by the philosophy of President Kennedy, whom he fully admires. He paraphrases, "Ask not what your school can do for you; ask what you can do for your country." Can he become even more self-confident and motivated following the practice of inquiry?

Lynne

Lynne is an anxious math student. A fifteen-year-old freshman, she has told me in confidence that she and algebra do not get along. Prone to leaving me notes in her folder that state the same message, Lynne and I have decided to meet after school for tutoring. Since she rides the bus, her father must pick her up on such occasions. This gives me an opportunity to meet her father before the first formal parent-teacher conference. He is very supportive of her learning and understands her nervousness. At this point she is given modified work in class where I work with her one-on-one as much as time allows. Her anxiety follows her every time she sets foot inside our classroom. When she is sent up to our room on an errand, she informs me, so honestly and forthrightly, that her heart pounds whenever she comes into our room. I begin to ease her anxiety with my kind, nurturing words and a plan of attack. Will the use of inquiry increase her self-confidence and motivation?

Ariana

As a fifteen-year-old freshman with cerebral palsy, Ariana is bright and engaged. She appears very confident and eloquent. She actively participates in class and is able to express herself abstractly. She confidently walks to the board and models a lesson even though her hand shakes when she slowly writes. Will the practice of inquiry in math increase her self-confidence and motivation even more? She has a one-on-one para-professional.

Brian

Brian, a senior, is a delightful young man whose autism and pervasive developmental disorder can cause frustration. With halting speech he participates in class with his para-professional as well as with me in a one-on-one situation. He is motivated to try to participate in class enactments following kind, supportive, graphically notated and colorfully highlighted math problem-solving. He has begun going to the board to answer problems. Can routine classroom questioning allow for the modification towards more active participation with his classmates? Will inquiry increase his motivation and self-confidence? He has a one-on-one para-professional.

Victoria

Victoria is a charming, invested freshman with cerebral palsy. She speaks in a quivering voice with very low volume. However, with adequate wait-time for processing, Victoria can successfully answer math problems and record the problem-solving. She is pleasant and has a big smile which she visits on me at ideal moments. Will the practice of classroom inquiry increase Victoria's motivation and self-confidence in not only math but also in her speech? Victoria has a one-on-one para-professional.

David

David is a fifteen-year-old with pervasive developmental disorder and a high level of anxiety brought on by a strong sensitivity to noise. He wears ear muffs to block out extraneous sound. Prone to loudly articulating his inner thoughts ("Are we done yet? I'd rather be at home watching TV. You don't love me.), David has a strong prior knowledge of math and can independently complete most assignments modified in length. However, his attention span to the class activities is fleeting. Will he partake in inquiry? Will the participation in classroom questioning increase David's motivation and self-confidence? David has a one-on-one para-professional.

Billy

Billy is a freshman whose disenfranchisement is currently slowly abating following kind, humorous, encouraging, and praise-worthy instruction. Billy's math skills are below grade level and his classroom participation is negligible and questions are usually answered with cool stares. Billy requires one-on-one encouragement and guidance to produce math work. Will the regular practice of inquiry increase Billy's motivation and self-confidence in the math classroom?

Jack

Jack is a sweet, compliant, ninth-grader with average math skills. He often responds to questions in math class although only when called upon. If he becomes frustrated, he puts his head down. However, he is often able to independently complete math assignments. Will the practice of classroom questioning increase his motivation and self-confidence to speak in class?

Bonnie

Bonnie is a highly-socialized, very pleasant senior. An engaged student with limited math skills, Bonnie actively seeks out help and perseveres in her problem solving. With the practice that she joyfully applies, Bonnie increases her math processing and math memory. However, for various reasons which have nothing to do with math, Bonnie can become very behavioral in class. Will the regular practice of classroom questioning further increase her academic self-confidence and motivation.

Grace

Grace is a delightful, sweetly-natured junior with not only close-to-average math skills, but also the abstract ability to make connections, draw conclusions, and confidently extend her knowledge. She states that rounding a number such as 1596 to 1600 is much like seeing that the year 1596 is almost the seventeenth century. However, she does not come up to the board to work and will only answer questions when she is called upon. Will the regular practice of inquiry further her motivation and self-confidence?

Ike

Ike is a delightful, friendly fifteen-year-old freshman with average math skills. He is invested, precise, and diligent. Ike's disability, higher functioning autism, effects his executive skills, making them laborious. Various repetitive movements can take him away from the assignment of the moment. A gentle reminder will bring him immediately back to the task at hand. He speaks in a halting manner and has a speech therapist to assist in this and the low volume of his voice. Will the regular practice of classroom questioning add to his motivation and self-confidence?

Chalk Talk **A Silent, Student-Run Activity**	**September 2009** **How Do I Feel About Mathematics?**
Ariana	I need a lot more practice with mathematics. Mathematics uses too many symbols that make me very annoyed! Too much to remember. Math is boring. Mathematics makes me fall asleep. Mathematics confuses me.
Bonnie	Mathematics makes me feel confident. My favorite thing to do in mathematics is adding and rounding up numbers. When you do math it will make you feel better about life.
Grace	Mathematics makes me feel more proud and courageous. My favorite things to do in mathematics is that I always do pre-algebra and geometry. Box and whisker plot is one of my favorite mathematics terms. I think that math is important to understand the situation about numbers and equations.
Ike	I feel happy about mathematics.
Lynne	Math makes me feel bored. I need help with it so I can understand it a lot better. Math makes me feel scared. Math makes me feel happy that I can learn it. (It) makes me feel happy to understand it.
Billy	Math is unimportant.
Brian	Math like this is new to me.
Ryan	I feel that math is very important to know about and be aware of. But it's very important not to be crazy about it.
Victoria	I feel confused sometimes.
Jack	Mathematics is easy.
Donald	I feel fine.

If the teacher's responsibility was to create an educational environment that allowed students to assume the mantle of responsibility for their own learning, the question begging to be answered was, will sustained classroom questioning by both the teacher/facilitator and, by extension, the students themselves enable student love of learning and ownership? This action research study was designed to observe the effective practice of inquiry through considered professional judgment, assessment, and evaluation. Extraneous variables and uncontrolled variables were not a contributing factor.

The ten inquiry sessions below illustrated the incremental growth in motivation and self-confidence within a special education mathematics class of ninth through twelfth graders. For privacy and confidentiality, the students' real names have been substituted with pseudonyms.

Inquiry Session #1

On Wednesday, October 7, 2009, the math lesson (Massachusetts Number Sense Strand, Standard 4.N.1) on rounding was modified to commence with the review of the mnemonic, which was designed to aid the students in remembering to replace the rounded place values with a zero or zeros. Previous knowledge was reviewed as lower-level comprehension questions.

Ms. Stohl: When the number selected needs to be rounded up, such as 36 to the nearest tenth, what is your strategy? Does the number in the tens column change? How and why?

Ariana: I see that the number in the ones column, the six, is larger than or equal to five, so I round up to 40.

Ms. Stohl: How specifically did you decide to round 36 to 40, Ariana?

Ryan: Try not to overanalyze it. 36 is closer to 40 than to 30.

Ariana: I realize that if I need to round up that the number in the tens column goes up by one.

Lynne: And you replace the six with a zero to hold the place.

Ms. Stohl: But when a selected number, for example 34 is rounded to the nearest tenth, does the number in the tens column change by subtracting one lIke it did when you rounded 36 to the nearest tenth and it became 40 by adding one to the three?

Bonnie: If I round down the three becomes a two.

Ms. Stohl: I understand how you came to that logical conclusion, Bonnie, but is there another way of looking at the rounding of 34 to the nearest tenth?

Jack: I think it's 30.

Ms. Stohl: Why would 34, rounded to the nearest tenth, be 30?

Grace: Because we are talking about numbers between 30 and 40. If you look on a number line of the numbers 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, and 40, you see that 34 is closer to 30 and that 36 is closer to 40. 35 is in the middle. I think the number line helps you to see *when* you have to change the number in the tens column and when you don't.

Ms. Stohl: If we round 371 to the nearest tenths, what do we first ask ourselves?

Billy: I think this process is too complicated.

Bonnie: 370! I am starting to get this because of the practice. Let me try another problem. You write, Ms. Stohl, and I will talk you through it....Four hundred and seventy two to the nearest tenths. The number in the tens column is seven. (An caret is placed to highlight the number seven.) I look to the right and see the number two and you place a arrow pointing down by the two which is the number which will turn into a zero because I have to round down.

Ms. Stohl: Is two less than five or greater than or equal to five, Billy?

Billy: It's less than five.

Ms. Stohl: Do you round up or down?

Bonnie: Up (wait time given), no, down to 470. (Ryan also repeats the correct answer simultaneously with Bonnie.) (An arrow is drawn pointing down before writing the equal sign. 472 ↓ = 470.)

Ms. Stohl (as a means of incorporating 21st century workplace skills): Why do we round numbers? What is the practical reason for doing this lesson?

Ryan: When we go shopping we need to be able to estimate if we have enough money. By rounding numbers before we add up our purchases, which is easier than adding up the actual prices, we can find out if we have enough money for the things we want to buy.

This was a hard concept for some students to realize, for it felt counter-intuitive. For many, rounding down means the number selected should decrease by one. Ariana, Ryan, and Lynne's articulate defense of the rounding operations helped their fellow students, as evidenced in Ariana and Lynne's verbal reiteration of the key concepts. Jack was then able to apply his new-found skill by solving a problem at the board and interpreting his method, albeit sheepishly and with prompting, to the class. Grace created a color-coordinated number line to show her classmates.

Inquiry Session #2

The inverse relationship of addition and subtraction within the addition of negatives (Mathematics Number Sense Strand, Standard: 6.N.12 Wednesday, October 14, 2009) was interpreted in the problem, two minus three (2 – 3).

Ms. Stohl: How would you rewrite this subtraction problem as an addition problem?

Victoria (slowly, very softly): Two plus a negative three.

Ms. Stohl: Would the answer be positive or negative?

Ariana: Negative.

Ms. Stohl: How do you know the answer will be negative? David, how do you know the answer will be negative?

David (loudly): Because there are more negatives.

Ariana: Yes, David, there are three negatives and only two positives.

Brian: You have more negatives, so the answer will be negative.

Ms. Stohl: Can everyone please create a number line to show the problem-solving method in the subtraction problem, two minus three?

With facilitation and modeling the students drew number lines, showing positive and negative infinity, plotting the first number, counting backwards (the addition of the negative) the amount indicated by the second digit, and noting the number they land on and plot, which was the answer. They also drew a line above the number line, noting the places they counted backwards.

Ms. Stohl: What is the answer to the subtraction problem two minus three?

Lynne: Zero.

Ms. Stohl: How did you get that answer, Lynne?

Lynne (coming up to the number line drawn on the board): I counted backwards three times from two...two, one, zero.

Jack: No, it is negative one.

Ms. Stohl: Jack, can you come up to the board with Lynne to demonstrate your method on the number line?

Lynne's demonstration showed that she started counting on the number two and then counted backwards. Jack showed Lynne and the entire class that the count starts to move immediately from the starting number and does not include that number.

(Lynne elected to come after school for tutoring once a week in math. She consistently made the same errors noting a problem with her working memory. She was diligent and in the one to one after school work she began to understand the mechanics of the number line. However, the homework given found her making a small mistake within each number line that prevented her from getting the correct answer. It was the hope that frequent questioning, followed by her verbal articulation as well as the art-spatial and kinesthetic intelligences of the number line would increase her memory and thereby her self-confidence. She was obviously motivated as noted by her weekly after school sessions.)

Ms. Stohl: Jack, how did you come to the conclusion that two minus three is negative one?

Jack: Because, when I add positive two and three negatives, the answer stays negative. I flipped the numbers and then slapped on a negative sign. Three minus two is one. So it is negative one.

Ms. Stohl: Did you see this answer on the number line, Jack?

Ariana: Yes, Ms. Stohl. Jack used the other method. He flipped the signs and simply subtracted and then placed a negative sign onto his answer. (Aside to me) How long have you been doing this? Loving math?

Ms. Stohl: Well, Ariana, I have been teaching math for eight years and with practice I am getting better at it and I am more and more able to understand different ways of explaining the different ways of seeing and interpreting math.

Ryan: Ms. Stohl, with your permission, I am going to help David by writing down the problems for him and then helping him solve them.

Ms. Stohl: Ryan and mathematicians, you know I take classes and I am working on a new college degree. One thing we learn is that there are steps to understanding. A man named Benjamin Bloom figured them out and the top-most understanding says that you have the deepest learning when you teach the material yourself. And, Ariana, that is what has happened to me. I gained the knowledge through teaching and trying to have you, my students, explain, interpret, and apply their learning. Mr. Bloom calls this teaching step *evaluating* and *creating*.

Ariana: That is how you can explain math so well.

Ryan: This is over thinking these math problems. You have to forgive Ms. Stohl, everyone, she went to college and she can't help herself. She wants to push us!

Ms. Stohl: Please rewrite these subtraction problems as addition problems and solve to show the addition of negatives and the inverse relationship of addition and subtraction. Illustrate each problem with a quick hand-drawn number line.

Addition of Negatives Worksheet	Rewrite as an Addition Problem	Answer
1. 2 - 3		
2. 5 - 4		
3. 15 - 16		

Addition of Negatives Worksheet	Rewrite as an Addition Problem	Answer
4. 20 - 30		
5. -7 - 1		
6. -8 - 2		
7. -1 - 4		
8. -5 - 5		
9.Extend your knowledge! -3 - (-3)		

Ms. Stohl: Actually, Ryan, not everyone can figure out math problems conceptually in their heads like you are able to. Some need to be able to look at a problem with their eyes not just in their mind's eye and still other students need to physically move points on a number line; hence, that is why I am asking for the number line for each problem.

Ariana had a stroke of genius which was praised as such. She stated that if you were having trouble making the infinity symbol, you could turn your paper and draw the number eight. When you turned your paper back, you would see the infinity sign.

Ms. Stohl: How much would you need to turn your paper?

Ariana: Ninety degrees.

The technique was demonstrated on a sheet of paper. Grace' beautiful number line was shown to the class, but it was also noted that a number line was a tool. It did not matter if it was perfectly executed, since it was simply a personal support. Therefore, if a student wanted to use a ruler he or she could, but it was not necessary. In fact. it was great if a number line could be drawn quickly to help a student “see” a problem better. Problems such as five through eight above, where two negative numbers were added, were shown on a number line that simply plotted zero and one to the right along with the positive infinity sign, and then showed the rest as negative numbers along the line. Further practice through an inquiry session will be needed for the students to feel comfortable using this modification of the number line.

On Friday, October 16, 2009 the quiz on the inverse relationship of addition and subtraction, which mimicked the previous day’s problems, was conducted.

QUIZ The Addition of Negatives	Score	Reworked Score
Ike	92%	100%
Lynne	83%	90%
Brian	100%	
Grace	100%	
Bonnie	43%	Had a rough day; refuses to rework
Ariana	70%	96%
Jack	100%	
Ryan	91%	Elated; does not feel the need to rework
Victoria	92%	Happy; does not feel the need to rework
Billy	23%	Does not rework
David	100%	

Inquiry Session #3

On Thursday, October 22, 2009, the inquiry instruction built on the students' prior knowledge of absolute values (Massachusetts Number Sense Strand, Standard 8.N.6. Note the increase in grade level learning) and provided an extension of their independent learning through the adding and subtracting of number sentences with absolute values. The students were asked to create number lines specific to the needs of the problems. Later, a negative sign was placed outside the absolute value as an extension of their learning.

Absolute Values in Addition Problems	Rewrite	Final Answer
1. $\|3\| + \|-5\| =$		
2. $\|-2\| + \|4\| =$		
2. $\|-2\| + \|4\| =$		
4. $\|-3\| - \|5\| =$		
5. $-\|2\| + \|4\| =$ $-2 + 4 = 4 - 2$ (introduced commutative properties)		

When the class solved #3 and #4 along with the extension problem #5 with careful rewriting from left to right (also an unstated review of simple PEMDAS), they still required an inquiry session of lower-ordered questions as guidance and reminders in the steps to add negatives. This was disconcerting since the previous lesson addressed the addition of negatives. Memory issues were abundant, but many students simply needed a quick refresher. The commutative property of addition was introduced when the addition of negative two plus four (-2 + 4) stumped the students.

Ms. Stohl: Students, who here has taken the T? What is it called when people take the T to and from work?

Ryan: Commuting

Ms. Stohl: So when people commute on the T to and from work, is the trip to work the same as the trip from work?

Ryan: The trip to and from work is twice the distance. If it takes two hours to get to work, the whole trip will take four hours.

Ms. Stohl: That is true. But also, is the trip to work (walking in one direction) simple the same trip only turned around to come home (walking the same distance in the opposite direction)? Is the trip the same coming as going? Is the commuting lIke going two plus four and turning around and going four plus two?

Ryan: Yes, the trip to work is 5 miles, so the round trip is 10 miles.

Ms. Stohl: Yes, Ryan that is true. Are you saying that the distance from home to work is the same as the distance from work to home? Commutative properties says you can "commute" -2 + 4 into 4 - 2, a problem that is recognizable. So what is negative two plus four? What is four minus two? Is negative two plus four the same as four minus two? Is four minus two equal to negative two plus four?

The class concurred that the two problems were the same. Further questioning regarding commutative properties was left for another day as confusion mounts and Ryan continued to state his addition of time and distance examples. At times, the practice of inquiry can create and expand misinformation. When time runs out, this faulty knowledge must be addressed during a later session.

Inquiry Session #4

Friday, October 23, 2009. The students were asked to write the math truth of absolute values by plugging in a number of their choice, $|-3| = |3| = 3$. This proved to be a challenging procedure for all of the students. Since this lesson was a part of a long block, where two fifty minute classes and broken up by lunch, the break for lunch proved fortuitous. A few students were able to follow through the inquiry session on using the variable x to create a math truth for all numbers: $|-x| = |x| = x$.

Ms. Stohl: What is the absolute value of 3? What is the absolute value of -3? Does three equal three? Therefore, does the absolute value of negative three equal the absolute value of three equal three? (This is the first time the students have been exposed to the conditionals in logic.) Can the same be said of the number five? Of the number eight? Of the number negative two? Of one hundred? And negative one thousand? If this is so, does the math truth that states $|3| = |-3| = 3$ work for any number? How can we write that? *Can* we write this? In algebra, what do we use to represent an unknown, any unknown?

Ariana: A variable

Ms. Stohl: What is a variable?

Lynne: A letter.

Ms. Stohl: What letter?

Lynne: x and y.

Victoria: Or a and b.

Ms. Stohl: What is the most common variable in algebra?

Ariana: x.

Ms. Stohl: Do you agree then that we can say $|-x| = |x| = x$ to algebraically explain the math truth about absolute values? (This is the first time the students have been exposed to expressing a number sense problem algebraically.)

Ariana: Yes, or like Victoria said, even $|-a| = |a| = a$ or $|-b| = |b| = b$.

Ms. Stohl: Here is your assignment: If we agree that the absolute value of negative three equals three and that the absolute value of three equals three, then do we agree that the absolute value of negative three equals the absolute value of three which both equal three?

The students found it difficult to understand that they needed to write the absolute value math truth using another example and not just copy down the example on the board with the number three. This assignment will be tried another day.

Inquiry often connected to constructivist learning whereby the students continued to figure out the answers to problems both individually and as a class, continued to link this learning to future endeavors in the classroom, and continued to find real world applications for mathematics. Leaving this lesson with loose ends informed the students that they would need to think about their thinking and organize their information for future lessons. The students began to realize their lessons were not concluded in finite 50 minute classes, but rather that they would not only need to use previous knowledge in review, but also they would need this knowledge to inform future learning. The students recognized that math builds on itself in a linear sloping manner.

The field notes continued to indicate that inquiry was increasing the students ability to identify strategies to solve their math problems thus building their self-confidence and motivation.

Inquiry Session #5

Tuesday, October 27, 2009. Ryan took one on one MCAS math prep daily after school until the math retest. The focus was on a test taking strategy: Evaluation through the more mundane process of plugging in numbers.

Plugging in numbers allowed a student to expand and solve problems that normally were unrecognized or difficult by realizing that this strategy would reduce a complex, unfamiliar problem into a simple problem of the utilization of the order of operations. Problem #1: If x equals 5, evaluate y = 3x + 4.

Ms. Stohl: Does this problem look difficult, Ryan? What does evaluate mean? If you saw a problem such as 3 x 5 + 4, how would you go about solving it?

Ryan: I would multiply first.

Ms. Stohl: Why?

Ryan: Because of PEMDAS, I would multiply 3 times 5 and then add 4.

Ms. Stohl: What answer would you get?

Ryan (recording through regrouping, but in no need of a calculator although he can use one per his IEP): 15 plus 4. (pause) 19.

Ms. Stohl: Could we say that 3 x 5 + 4 = y?

Ryan: No.

Ms. Stohl: Could we say that 3 x 5 + 4 = 19 and call 19, "y?"

Ryan (puzzled).

Ms. Stohl: If a variable is a letter that represents a number, could the answer 19 be represented by the letter "y?"

Ryan: Yes. So, 3 x 5 + 4 could be y.

Ms. Stohl: And does y = 3 x 5 + 4? Well, it does because if one side of an equation equals another, we can flip the equation around and get the same answer. Getting back to the original problem....what sounds like an advanced problem is nothing more than PEMDAS. If you are asked to solve for y, what are the test makers asking you?

Ryan: To solve the problem.

Ms. Stohl: And if they tell you what x is, what is the first step?

Ryan: Plug in that number for x and figure out the problem with PEMDAS.

Wednesday, October 28, 2009. Ryan's MCAS Math Prep continued by understanding perimeter in all of its guises.

Ms. Stohl: What is perimeter? Let's look at these examples of two-dimensional figures and use the string pictorial where I draw a "string" around a drawn object and then pretend to pick up the ends and open the string up and lay it along onto a ruler to measure. If we have a square with a side of 3 units, what is its perimeter? Do not forget to note the unit of measurement.

Ryan: 3 + 3 + 3 + 3. (Using the calculator, he finds the answer is 12 units.)

Ms. Stohl: If we have a rectangle with sides of 3 and 4 inches, what is its perimeter? If this side is three what is this side opposite the side of 3 inches?

Ryan: Three. Inches.

Ms. Stohl: And this side opposite the four-inch side?

Ryan: Four. Inches.(He labels the drawing.)

Ms. Stohl: What is the perimeter; what is the distance around the rectangle?

Ryan: Three plus four plus three plus four....14 inches.

(The formulas for perimeter of a square and rectangle were not differentiated. The best method of test-taking with so little time to prep was to maintain one methodology. Ryan's memory was not his strong point. His diligence and knowledge of math facts, however were quite strong.)

After, trying a few more examples of squares and rectangles as well as triangles, an algebraic perimeter problem was assigned. Ryan had previously worked on combining like terms and simplifying expressions.

Ms. Stohl: Let's try this algebraic perimeter problem: A rectangle has the sides of x and x + 4. What is its perimeter?

Ryan did not know how to begin. He was reminded that perimeter is the distance around; he referred back in his notes to the perimeters of rectangles.

Ms. Stohl: Is this a rectangle? How do you find the perimeter of a rectangle? ....If you add up the sides, how would you add up the sides of this rectangle? What kind of problem could you create?

Ryan (slowly and tentatively): x? ....plus x + 4...plus x....plus x + 4?

Ryan needed to be reminded that this problem was now a problem of combining like terms. He referred back in his notes for examples of these problems.

Ms. Stohl: How many exes do you have and how many fours? (I art-spatially circle the exes and draw a square around the constants, the fours.) Ryan is now able to figure out that there are four exes and that four plus four equals eight. He writes 4x + 8 units.

Ms. Stohl: If a rectangle has two sides that are equal in length and two other sides that are equal in width, how do you find the perimeter? Why would the method change if you see variables? It wouldn't!

Ryan had shown that the interactive approach to learning within the inquiry classroom allowed him to construct his learning in MCAS prep. This was ideal, for he would need to independently identify those problems in the test environment. He came to understand that evaluation would provide him the strategy to solve many difficult problems that addressed concepts he was unfamiliar with but where the required formulas were provided for him.

Ms. Stohl: Now let's try this problem. Velocity=Distance/Time (v=d/t ; where d=distance and t=time). This is nothing more than the DIRT formula solved for rate of speed or velocity and given to you within the problem. Again it requires you to plug in the information given.....Ryan passed his Math MCAS Retest with a 220.

Inquiry Session #6

Monday, November 2, 2009. (Massachusetts Patterns, Relations, and Algebra Strand, Standard 6.P.2.) Students would understand variables, terms, algebraic expressions, coefficients, combining like terms as well as simplifying, and evaluating expressions with the ability to speak in the language of math when constructing algebraic answers through inquiry.

Ms. Stohl: What is the most common variable?

The class agreed on x as the most common variable, with y and z and a,b,c following x as often-seen letters representing numbers.

Ms. Stohl: Can any letter be a variable?

The class came to the consensus that, yes, any letter could be a representative variable.

Ms. Stohl: Do we ever assign a letter for a number to help us keep track of what we are talking about? What about algebra in geometry? Do you find you need algebra in geometry?

Some students agreed you can use algebra in geometry, but Ariana brought up another connection when she misheard the word *geometry* as *geography*. This is an example of a student response as an error leading the discussion in inquiry.

Ariana: In geography you can use the distance formula.

Ms. Stohl: Yes! And what do the variables in the distance formula mean? What does these letters tell you?

Ariana: Distance is the d.

Ms. Stohl: If d = rt, what does the r and the t stand for?

Ryan: t is the time.

Jack: r is the rate.

Ms. Stohl: The rate of what?

Jack: How fast....

Ms. Stohl: Yes, the rate of speed. Excellent. What if, we did not assign *d* for distance and *t* for time and *r* for rate? What if we used the most common variable x for distance and y for time and z for rate? (Writing on the board) And what if we then had to solve for time? We would manipulate the equation and solve for time by writing y = x/z. How do we keep track of what we are solving for? It is impossible to keep track of what we are doing! (Everyone agrees with a great deal of noise.) Now back to geometry. If we have a square, what do we call a side? What variable makes the most sense to assign to stand in for the side of a square?

Ms. Stohl: Ike what do we label a side when we are working with a square and trying to find its area or perimeter?

Ike: What? (He is preoccupied with his usual rubbing and rolling together of eraser bits.)

The question was repeated and the class allowed Ike the processing time.

Ike: s?

Jack: s for side.

Ms. Stohl: If we have a rectangle what do we call the sides and what variables do we use to represent the sides? Does this help us keep track of what we are doing? So variables have another purpose besides representing a number.

Ariana: We have to use a variable that makes sense so we can keep track of what we are solving for.

Ariana was able to deduce and concisely reiterate the purpose of this distance formula lesson within the larger learning format of the construction of knowledge of the purposes behind variable usage through the inquiry sessions that were conducted in the classroom. Higher level mathematics thought was becoming evident in the students' dialogue through interactive learning within our inquiry community.

Inquiry Session #7

Tuesday, November 3, 2009. Coefficients were the subject of the day. The definition and examples were initially touched on the day before. This session noted the heightened frustration of one student.

Ms. Stohl: Let's talk in the language of mathematics. Here on the board are some expressions we have defined and described and some that may be new. If a coefficient is a number that multiplies a variable, what is the coefficient in the term 2x?

Bonnie: The coefficient is 2 and it multiplies 2 times x.

Ms. Stohl: Like yesterday, here are five algebraic expressions. Please list the coefficients in each expression and simplify if you can.

Identify the Coefficients	List the Coefficients as parts of a set	Simplify (If you can!)
1. 2x + 4		
2. 3x + 2x		
3. 4a + 6b		
4. 9y - 4y		
5. 2x +3y - 5y		

Ms. Stohl: In number 4, what are the two coefficients?

Jack: 9 and 4.

Ms. Stohl: Does everyone agree? What is another way of looking at a subtraction problem? Isn't a subtraction problem the same as an addition of a negative?

Jack: 4y?

Ms. Stohl: Is the minus sign a part of the coefficient of 4y?

(Jack gave up and put down his head.)

Ms. Stohl: Jack, it may seem like I ask a lot of questions. (The entire class nodded in agreement.) Please stick with it! It is the fun of discovery. Try not to get discouraged, Jack. We all struggle at times. All of your fellow students are working on this, too. It is OK to make mistakes. It is great that you are trying to figure out the answer. I love working on this with you, Jack, and all of you, class. (Jack looks up.) So, what is the other coefficient in this expression?

Lynne (tentatively): Negative 4?

Victoria (conclusively): Negative 4.

Ms. Stohl: Yes, negative four. You have to take the negative sign with the term and therefore with the coefficient which is a part of the term. Why?

Ariana: Because a subtraction problem is the addition of a negative?

Ms. Stohl: Yes! Do you remember, students, that we covered this a few weeks ago? A subtraction problem is actually the addition of a negative. Now, what are the coefficients in number 5, 2x + 3y - 5y?

Everyone chiming in: 2, 3 and negative 5!

Ms. Stohl: So what is a coefficient once again? What does it do to the variable?

Bonnie: A coefficient multiplies the variable.

Ms. Stohl: Well said, Bonnie, using the language of math.

Bonnie: I am having a good day....

Ms. Stohl: And finally, how could we rewrite number 4, 9y - 4y, as an addition of a negative expression?

Bonnie: 9y plus negative 4y.

Ms. Stohl: David, do you agree with Bonnie?

Ms. Stohl: (David needed to be refocused as he raised his ear muffs?) David, how could you rewrite the variable expression 9y - 4y as an addition problem?

David (loudly): 9y plus a negative 4y.

In this inquiry session, the push of classroom questioning caused Jack to become frustrated. His fellow students, however, chorally modeled the success of verbal confidence in articulating the language of mathematics. Jack renewed his motivation by picking up his head and listening, if not actively taking part.

Inquiry Session #8

Ms. Stohl: (Tuesday, December 1, 2009) Let's discuss the difference between two math verbs that seem to be problematic. What does it mean to simplify an algebraic expression versus evaluate an algebraic expression.   In the Calculator-Free Zone, students, please simplify and then evaluate the following algebraic expressions:

Algebraic Problem	Simplify	Evaluate, if x = 2 Show your work
1. 2x + 3x		
2. 10x + 10x		
3. 4x + 2x + 3x		
4. 5x - x		
5. 6x + 3x - 4x		
6. 2x - 5x		
7. 3x + 3x + 5y		
8. -7x + 8x - 2y		

Ms. Stohl: Should you believe everything I teach you?

Puzzling looks, disagreement ("What?"), a collective gasp.

Ms. Stohl: You should not always believe me; you should not always believe what I teach you. Yes, I may explain that you add like terms in algebra, and it may make sense to you when I explain that if you have two apples (2a) and I give you two more apples (2a), then you have four apples (4a). However, until you prove it , there may be some doubts. How do you prove that 2a + 2a equals 4a? (Silence.) You plug in a value for a and if both sides evaluate down to the same real number equaling the same real number, then you have proven that like terms can be combined. We will discuss this further when we start to evaluate in the next problems.

Ms. Stohl: Now we need to plug in a value for x so we can solve the expression for a real number. What number should we choose?

Jack: One.

Ms. Stohl: Why, one?

Jack: Because it is the easiest number to multiply by.

Lynne: We could use two, too.

Ms. Stohl: Absolutely, and if we had a y to evaluate as well, we would choose the number two. What is another reason why we would want to evaluate an expression with the simplest of numbers?

Ariana: In science the formulas can have very big numbers, so to plug in a simple number with zeros attached again allows for easier calculation.

Ryan: Don't mind Ms. Stohl with her fancy language; she went to college. Just use common sense when doing math.

Ariana: We could also say we replace a variable with a number or value.

Ms. Stohl: Once again, well stated, Ariana. What is another word we can use instead of plug in a number for x?

Grace: Substitute?

Ms. Stohl: Absolutely. Again, well stated! We can substitute, replace, or simply plug in a number or value for x. (Inquiry was also shown to be a way in which students could use their prior knowledge and instruct their fellow students.) Following this warmup, students please use your self-chosen value for x and then evaluate the following expressions, if x = 1.

Algebraic Term or Expression	Evaluate, if x = 1 Show your work
1. 4x	
2. 5x	
3. -2x	
4. 7x	
5. -x	
6. 4x + 3x	
7. 5x - 2x	
8. 6x - 5x (Easy!)	

Ms. Stohl: Why is number 8 marked "Easy?" Because, if simplified first, it results in the answer, x, and since x equals one, then the answer is one. No plugging in is necessary!

Ms. Stohl: How do we prove that we can combine like terms?

Ariana: I think that if we evaluate an algebraic expression and get an answer we can compare that number to the number we get after we simplify the expression and substitute the value for x.

Ms. Stohl: What do you predict, Ariana?

Ariana: That the numbers will be the same or equivalent.

Ms. Stohl: How do we define these equivalent number answers?

Bonnie: They're real numbers.

Ms. Stohl: Yes. And the numbers we are asked to replace or substitute, can the number be one? Can it be twelve? Can it be negative five? Zero? Can it be negative 1.5?

The students all answer yes as the above questions were asked.

Bonnie (teasing): But can we believe you, Ms. Stohl?

At the end of the class it was announced that tomorrow the class would be conducting an experiment and answering the question: How many drops of water from a pipette can you fit on the head of a penny?

Ariana: But Ms. Stohl, this sounds like science; this is math class.

Ms. Stohl: Ariana, once again you are so astute. First, thing tomorrow I will discuss your question. (The words *interdisciplinary* and *integrated* are written on the board to pique the students' interest.)

In comparing the two assignments, the students realized that they would get a real number answer when they evaluated, but would not when they simplified. When they simplified, they would simply shrink down the terms to their smallest number. Often they started at two and three terms and ended up with one term. But if there were terms that were unlike, then their answer would reflect the number of unlike terms. For instance, in #7, 3x + 3x + 5y would be simplified from three terms to two terms: 6x + 5y. Inquiry was providing the road to constructivist learning where the students vigorously built their own knowledge.

Inquiry Session #9

Wednesday, December 2, 2009. Long Block (96 minutes broken by 30 minutes of lunch). Cohesion Experiment. (Massachusetts Math and Science Standards)

Ms. Stohl: Look at the head of a penny and the pipette tool you will use in the experiment's test. Let's make predictions and I will record them on the board in answer to the question: How many drops of water from a pipette can you fit on the head of a penny? On the science data sheet, list your fellow students' names and record each classmate's predictions while also including a heading for Test #1 and Test #2.

After they recorded their prediction and those of their fellow students, the students broke into two groups of five students each. There they each tested their predictions while the other students watched and helped to keep count. The students recorded the data from each test. They then returned to their desks where they shared their data with the other group. The students then took out their calculators and together they found the mean, median, mode, and range of the prediction data and the Test #1 data. (Not each student had the time to complete Test #2.) They found that the average prediction was 5.4.

Ms. Stohl: 5.4 what?

Billy: Drops. (Billy was showing the greatest change in academic self-confidence and motivation.)

Ms. Stohl: Yes, Billy! We have to remember our units and this helps us remember what we are talking about, what we are keeping track of, much like we said when discussing algebra in geometry and the distance formula.

The students found that the average drops in Test #1 was 24.567. Their data rounded to the nearest thousandth also was a valuable lesson in math and science data recording.

Ms. Stohl: As your math classes get more and more advanced you will find you will be asked to routinely round your answers to the nearest thousandth.

Bonnie (teasing): Should we believe you, Ms. Stohl?

The students recorded the two means, medians, modes, and ranges on their data sheets (both their own data and that of the class as a whole) and were encouraged to include any calculations for they need to show their work. As scientists, they also needed to draw and label an illustration of what was happening to the water on the head of a penny. They would label the actual term for the bubbling of the water in the constructivist discussion of the description of the phenomenon after the break for lunch.

On a scientific definition graphic organizer, the students began to brainstorm the words they were using during the experiment to describe what was happening to the water on the head of the penny. The list began with Ariana's eloquent description:

Ariana: We can say that the water molecules are being dispersed on the head of the penny.

And then Jack and Grace weighed in.

Jack: It formed a ball.

Grace: It looked like a bubble.

Inquiry as a classroom instructional paradigm displayed positive student motivation and self-confidence as the students themselves ran the experiment through their repeated predicting and questioning. *Interdisciplinary* and *integrated* were defined and put into the context of doing science in math class because math is the language of science. The students were provided with the physics term *cohesion,* which the students added to their graphic organizer. Now in their discussions the students knew, without being encouraged, to use the term *cohesion* in future discussions. The students were sent home with a self-evaluation graphic organizer to fill out regarding their learning in the experiment for their next class meeting.

Thursday, December 3, 2009. The students began a whole-group brainstormed Collins write on the cohesion experiment. The interdisciplinary Cohesion Experiment Collins write below, along with the comparative Algebra Collins write that follows, assessed student motivation and self-confidence through their articulate explanation, in-depth understanding, abstract interpretation, and cohesive application of math and science facts and predictions. Ryan wrote a paper on the cohesion experiment experience.

Collins Write **Cohesion Experiment** **FCAs**
1. Record your prediction and specific data, compare these to your fellow students' data, and find mean, median, mode, and range in both sets of data. 30%
2. Describe the experiment, including a labeled illustration. 40%
3. Note your conclusions about the phenomenon of cohesion. 30%

Inquiry Session #10

Monday, December 7, 2009. The students continued to respond to inquiry, began to self-confidently phrase questions themselves, and to illustrate their growing motivation in tackling tough, abstract problems, as well as to demonstrate a blossoming self-confidence in taking academic risks. Jack insisted that the evaluation of $2x^2$, if $x = 3$, was 36.

Ms. Stohl: I understand how you got this answer, Jack, but like it is in "math world," there is only one right answer, and 36 is not the correct answer. (Bluntness was now accepted and humor could be used. Often when wrong answers occurred, especially in easy computation, planets spinning wildly out of control could be modeled.) But, your mistake is wonderful, Jack, because you are letting us understand how numbers work even better than we currently do!

Jack: But I don't get it.

Ms. Stohl: Let's back up, students. If $x = 3$, what is x^2?

Lynne: Three times three. Nine.

Ms. Stohl (illustrating 3 x 3 = 9 on the board): What did you do to find the problem three times three?

Lynne and Ariana: You substitute three for the variable x.

Ms. Stohl: What is the evaluation of 2x if x equals three?

Billy: Six.

Ms. Stohl: How did you get that?

Billy: Multiplication.

Grace: You replace x with the number three and then multiply two times three and get six.

Ms. Stohl: If the two is attached to the x by multiplication and the second power is attached to the x noting its square, does it follow that the second power exponent is also attached to the coefficient two?

Jack: Yes. I don't get this.

Ariana: Since you said 36 was not the right answer, then I would say that the coefficient two does not go with the exponent two.

Ms. Stohl: If that is so, and (pointing to the board) the coefficient two is not acted upon by the exponent two, then what is $2x^2$?

Grace: Two times x squared.

Ms. Stohl: What is two times x squared?

Wait time.

Ms. Stohl: What is x squared times two?

Ariana: X squared times two is three squared times two and three squared times two is nine times two which is eighteen.

Ms. Stohl wrote Ariana's instructions as she said them on the white board.

Ms. Stohl: This lesson is also an opportunity to once again discuss the commutative property of multiplication. If, as Ariana stated, x squared times two equals eighteen, does two times x squared also equal eighteen? (This was also illustrated on the white board.)

Ryan: Oh, Ms. Stohl, with your fancy language. Just look at it on the board and you can see that, yes, the two are the same.

Ms. Stohl: Can anyone state a simple example of the commutative property of multiplication?

Billy: Two times one equals one times two.

Ms. Stohl: Why does $2x^2$ equal $x^2 2$?

Ariana: Because if x equals three then eighteen equals eighteen.

Ms. Stohl: Who does not understand this?

Jack: I see this, but I still don't know why the answer isn't 36.

Ms. Stohl: Great, Jack. Let's explore further! Let's look at these two problems. Are they different?

Ms. Stohl writes on the white board two problems: $2x^2$ and $(2x)^2$ and asks if there is a difference between the two problems.

Lynne: They are different.

Ms. Stohl: Yes, how?

Grace: Because of PEMDAS the parenthesis tells you to multiple two times x.

Ariana: Two times x, if x equals three, is six and then you square the number six and six times six is thirty-six.

Ms. Stohl: How does that problem compare to $2x^2$?

Bonnie: $2x^2$ is two times x^2.

Lynne: x^2 is nine.

Bonnie: Two times nine is eighteen.

Ms. Stohl: Does eighteen equal thirty-six?

Everyone: No!

Ms. Stohl: Therefore, what can you conclude?

Ariana: We conclude that $2x^2$ does not equal parenthesis 2x parenthesis squared.

Ms. Stohl: What an incredible class you are! Well done!!

A whole-class, brainstormed Collins write concluded this lesson. Through the practice of inquiry, the students were able to take their oral arguments and reflect them in their defense of the question, does $2x^2 = (2x)^2$? Every student participated. Those who did not voluntarily, were asked to contribute through the use of both lower and higher ordered questions.

Collins Write **Does $2x^2 = (2x)^2$ if $x = 3$**
1. Demonstrate the fallacy in the equation. 30%
2. Explain why the two terms are not equivalent. 40%
3. Defend your answers through the use of PEMDAS. 30%

By December, the students' responses to the Chalk Talk question, "How do I feel about mathematics?" had become more eloquent and self-confident. Their lengthier, positive, emphatic replies also reflected their new or renewed motivation. Ariana and Lynne were able to reply to a comment. In addition, Lynne continued to reflect on math in her diary and she no longer felt anxiety every time she set foot in the math classroom. Billy showed the most important leap from a student who first felt that math was unimportant to a student who claimed, "Don't ever give up learning math. Math is the best thing in school for me." However, his written work had only improved by a small increment. Victoria, who in September claimed math was confusing, in December noted that although math could be easy as well as hard, it was now her favorite subject. She was able to actively participate even though her disabilities made speaking difficult and strenuous. David calmed down in class and was able to feel the self-confidence to focus and learn. Ike and Jack shut down less often although they both still could require additional encouragement to lift their heads back up and share their knowledge. Grace and Brian displayed daily motivation to participate in inquiry and work on the board as well as the self-confidence to add unique points of view to the study of mathematics. Bonnie's behavioral episodes had lessened and her focus, desire, and participation gladly increased. And finally, Ryan continued to grow in his motivation and strong self-confidence to put math into the written word.

Chalk Talk A Silent, Student-Run Activity	September 2009 How Do I Feel About Mathematics?	December 2009 How Do I Feel About Mathematics?
Ariana	I need a lot more practice with mathematics. Mathematics uses too many symbols that make me very annoyed! Too much to remember. Math is boring. Mathematics makes me fall asleep. Mathematics confuses me.	Ms. Stohl makes math easier to learn. I feel more confident solving math problems. Math is becoming much easier for me. Thank you for making math easier, Ms. Stohl. Now math is easier for me. Math still confuses me a little bit but it is much clearer and more understandable now. Thanks to Ms. Stohl, math is becoming much simpler. Math is becoming more fun to learn. Ms. Stohl makes math more fun to study. I like answering her questions.
Bonnie	Mathematics makes me feel confident. My favorite thing to do in mathematics is adding and rounding up numbers. When you do math it will make you feel better about life.	I love to do mathematics. Mathematics is my strength. Mathematics is my favorite subject. Algebra is my favorite part of math.
Grace	Mathematics makes me feel more proud and courageous. My favorite things to do in mathematics is that I always do pre-algebra and geometry. Box and whisker plot is one of my favorite mathematics terms. I think that math is important to understand the situation about numbers and equations.	Maybe it is why good way to have an in here so I decide to take another algebra class next year. I felt that math is way hard but I always know about algebra that they have variables, box and whiskers plot, and you simplify. Square root is so difficult because I just didn't understand about it. **Ariana**: I agree. **Lynne**: True. Ms. Stohl is the best and most beautiful math teacher in the whole wide world!
Ike	I feel happy about mathematics.	I feel that math is great.
Lynne	Math makes me feel bored and scared. I need help with it so I can understand it a lot better. Math makes me feel anxious. Math makes me feel happy that I can learn it. (It) makes me feel happy to understand it.	I am glad I am getting help in math. I feel I can understand it more. Math is a lot of fun. Math is a little easier for me now. Math makes me feel happy. I feel a lot better about math. Math is beginning to be my favorite subject. I never liked to answer questions before.

Chalk Talk **A Silent, Student-Run Activity**	**September 2009** **How Do I Feel About Mathematics?**	**December 2009** **How Do I Feel About Mathematics?**
Billy	Math is unimportant.	Don't ever give up learning math. Working with Ms. Stohl has gotten me learning math better. No joke, people. If you put your head together, math is easy. Me, I didn't like to learn math; you just have to work hard. Don't ever give up learning math. Math is the best thing in school for me. It is.
Brian	Math like this is new to me.	I like math and to go to the board.
Ryan	I feel that math is very important to know about and be aware of. But it's very important not to be crazy about it.	Math is very easy to learn; if you have the right teacher like Miss Stohl. I like to put the language of math into my Word projects and explain what we learn in class.
Victoria	I feel confused sometimes.	Sometimes it is easy and sometimes it is hard. Math is my favorite subject.
Jack	Mathematics is easy.	(Could not think of anything to write at this time.)
David	I feel fine.	I feel fine.

The formative, baseline student questionnaire from September 2009 and the summative student questionnaire repeated in December of 2009 were compared in the charts that follow. This was the final qualitative method to take into account whether the practice of inquiry, or classroom questioning, in the special education self-contained mathematics classroom reflected an increase in student motivation and self-confidence.

FORMATIVE AND SUMMATIVE STUDENT QUESTIONNAIRE
Baseline and Formative: September 2009
Summative: December 2009
Inquiry and Multiple Intelligences in the Classroom: A Model of Learning through Classroom Questioning and Inquiry/Constructivist Multiple Intelligences Activities.

On these pages you will be asked to rate how you feel about being questioned in the classroom and what you have gained academically from becoming a member of the inquiry and inquiry/constructivist multiple intelligences community.	
The Rating Scale 4 ☝ ☝ 3 ☝ 2 ☟ 1 ☟ ☟	
Select ONE of the following for each prompt in each category.	
4 ☝ ☝	I strongly agree with this statement.
3 ☝	I agree with this statement.
2 ☟	I disagree with this statement.
1 ☟ ☟	I strongly disagree with this statement.

A. LEARNING IMPLICATIONS OF CLASSROOM QUESTIONING and MULTIPLE INTELLIGENCES/CONSTRUCTIVIST LEARNING.

1. I have learned to form ideas with more confidence.

2. I have learned to participate regularly.

3. I am more motivated to learn.

4. I have learned to enjoy this subject matter more.

5. I have gained self-confidence as a student.

6. I remember information better.

7. I can link information together better.

Student Participant	September 2009	December 2009
Ariana	4 3 4 4 4 3 2	4 4 4 4 4 4 4
Bonnie	3 3 3 3 3 2 3	4 3 4 4 4 4 3
Grace	3 4 4 3 4 2 4	4 4 3 4 4 4 3
Ike	Became frustrated	1 2 4 3 2 3 3
Lynne	3 3 3 4 4 1	4 2 4 4 3 2 2
Billy	4 3 1 3 3 3 3	4 4 4 4 4 4 4
Brian	1 3 4 3 3 4 3	4 3 3 3 2 4 3
Ryan	4 4 4 4 4 4 4	4 4 4 4 4 4 4
Victoria	4 4 4 4 4 4 4	4 4 4 4 4 4 4
Jack	3 4 4 3 3 4 4	3 4 3 3 3 3 4
David	4 3 4 3 4 3 4	4 4 4 4 4 4 4

B. LITERACY IMPLICATIONS OF CLASSROOM QUESTIONING and MULTIPLE INTELLIGENCES/CONSTRUCTIVIST LEARNING.

On this page you will be asked to rate on how you feel about speaking, writing, and listening in class following the practice of classroom questioning and multiple intelligences.

1. I communicate more clearly.

2. I can debate more confidently.

3. I can form opinions more confidently.

4. I can make predictions more confidently.

5. I am more motivated to listen, learn, and participate.

Student Participant	September 2009	December 2009
Ariana	3 4 4 4 3	4 4 4 4 4
Bonnie	4 2 3 2 3	4 3 4 3 3
Grace	4 3 1 2 2	3 3 3 4 4
Ike	Became frustrated	1 2 4 4 2
Lynne	3 2 3 3 3	4 3 1 3 4
Billy	3 2 3 4 4	4 4 4 4 4
Brian	3 2 1 2 3	3 1 1 1 1
Ryan	4 4 4 4 4	4 4 4 4 4
Victoria	4 3 3 3 4	3 4 4 4 4
Jack	4 4 4 3 3	3 3 3 3 4
David	4 3 4 3 4	4 4 4 4 4

C. PERSONAL ACADEMIC AND COMMUNICATION IMPLICATIONS OF CLASSROOM QUESTIONING and MULTIPLE INTELLIGENCES/CONSTRUCTIVIST LEARNING.

On this page you will be asked to rate your overall confidence and motivation in your academic life.

1. I feel more confident overall as a student.

2. I participate more often overall in my classes.

3. I ask more questions overall in my classes.

4. I am more motivated overall in my classes.

5. I have more investment in the discovery of new information in my classes.

Student Participant	September 2009	December 2009
Ariana	4 4 4 4 3	4 4 4 4 4
Bonnie	3 3 3 3 3	4 3 3 3 3
Grace	4 4 4 3 4	3 4 4 3 4
Ike	Became frustrated	2 1 4 3 2
Lynne	2 3 1 3 3	3 4 1 4 3
Billy	3 3 3 3 3	4 4 4 4 4
Brian	3 3 1 3 3	3 3 1 3 2
Ryan	4 4 4 4 4	4 4 4 4 4
Victoria	4 4 3 4 4	4 4 4 4 4
Jack	4 3 4 4 4	3 3 3 3 3
David	1 3 4 2 4	4 4 4 4 4

D. CULTURAL IMPLICATIONS OF CLASSROOM QUESTIONING and MULTIPLE INTELLIGENCES/CONSTRUCTIVIST LEARNING.

And finally, in this section you will be asked to rate your self-confidence when you interact with your academic peers, family and friends as well as your motivation to share your knowledge.

1. I have the self-confidence to communicate clearly about classroom discoveries with my academic peers, family, and friends.

2. I have the motivation to teach my academic peers, friends, and family the material I have learned.

3. I think about what I will communicate and how I will communicate outside of school.

4. I feel self-confident and motivated to be an active citizen in a democracy of informed citizens.

Student Participant	September 2009	December 2009
Ariana	4 4 4 4	4 4 4 4
Bonnie	3 3 3 3	4 4 3 4
Grace	4 3 3 4	4 3 3 4
Ike	Became frustrated	2 4 3 2
Lynne	2 2 3 3	3 1 2 1
Billy	3 3 3 3	4 4 4 4
Brian	3 3 3 3	1 2 1 1
Ryan	4 4 4 4	4 4 4 4 Yes Yes Yes Yes
Victoria	4 4 3 3	4 4 3 3
Jack	4 3 4 4	3 2 3 2
Donald	4 3 2 2	4 4 4 4

The former four charts noted positive change from agreement to strong agreement as well as from disagreement to agreement or strong agreement across both the student population and the various prompts: implications in learning, literacy, personal academic and communication, as well as culture. Although some prompts did elicit a drop-off in concurrence, these were negligible when compared to the much greater growth in agreements on the benefits of inquiry to the students' overall motivation and self-confidence.

Conclusion

Prior research has provided meager evidence that classroom questioning yielded success in raising student motivation and self-confidence. Therefore, this action research study on sustained inquiry in the special education mathematics classroom provided a needed addition to the research base, for it showed a steady increase in students' effortful, authentic growth in motivation and self-confidence following three months of almost daily questioning sessions.

Rather than focus just on math facts, computation, and the one correct answer, this study's eleven math students were asked to leave behind their learned helplessness and disenfranchisement and to start anew by constructing their own knowledge by answering multiple series of questions. For their motivation and self-confidence to grow, the students had to learn to appreciate their own academic risk-taking and their possible failure in front of their peers. Starting with lower-order questions tailored to their ability levels and building towards constructed, higher-order learning, the students began to actually enjoy the process of possible failure as they reached to answer the questions, for they came to realize that failure was the pathway to the realization and articulation of the correct mathematical answer. Any negative feelings of inadequacy were steadily eliminated.

Success was fun and it felt great! Humor and kidding around found their way into these seriously focused, standards-based math classes. The wrong answer was amusingly equated to the planets spinning out of their orbits. With this funny analogy, failure became accepted. When an erroneous reply or process was articulated, these budding mathematicians could laugh at the thought of the Earth flying out into space, for the facilitator had stated that the universe was run by the same math concepts as the ones they were questioning. So, therefore three times eleven cannot be thirty-four since the solar system would be thrown off its orbit and the planets would find a direct path out into space. Three times eleven had to remain thirty-three. Eager to solve the puzzles of math, the students were able to refocus after these flights of fancy with renewed motivation and unwavering self-confidence.

Through the establishment of an inquiry community, these students discovered their own self-actualization. The beginning of the year found students who were anxious, stressed, defeated, and quick to shut down. Soon after the start of the implementation of sustained inquiry, happy and eager students entered the classroom having discovered their budding math abilities. The students ultimately became very comfortable with and engaged in continuous, rational questioning. For, not only were their classes peppered with challenging higher-ordered questions, but also the rest of their lessons were filled with comfortable lower-ordered guiding questions. The students began to talk about the fun they were experiencing in math, while their successes programmed them to address themselves as mathematicians. This brave new math world was indeed an ecopod of the motivated and self-confident.

These experiences in sustained classroom questioning and actively involved articulation highlighted many of Bloom's taxonomy. Comprehending, understanding, applying, and analyzing information led to synthesizing, evaluating, and creating. Inquiry became the process by which the students were motivated to connect their mathematics knowledge through the metacognitive understanding of their own thinking. With self-confidence they embraced the before unheard of interdisciplinary study of science and English within math as well as the integrated study of art within math.

Comprehending, deducing, recalling, classifying, comparing, and generalizing were evidenced during each session. Like Dewey, and Socrates way before him, this inquiry process recognized the student as the center of learning and the teacher as the facilitator. How the students learned trumped what they came to know. The cooperation and collaboration experienced by the students in this inquiry learning community provided even more building blocks to constructing their own knowledge and ultimately to achieving considerable self-confidence and greater motivation. Likewise, these same experiences created the habits of mind of independent, creative thought and team-building parameters of 21st century skills. Lifelong learning, which enables a competitive, problem-solving workforce, should follow.

As a progressive educator and a proponent of the inquiry-constructivist method of learning, this participant observer's action research allowed the formal illustration of what was previously only personal anecdotal evidence of the successes of inquiry in the classroom. The comparison of positive change between the formative and summative student questionnaire responses and the students' September versus December Chalk Talk writings along with the qualitative inquiry dialogues recorded in the field notes led to these refined findings. Even though this research period ended, inquiry as an instructional best practice in the classroom was not abandoned. Classroom questioning continued to be employed on a daily basis within this research class as well as in other math classes. This participant/researcher also would embrace the next formal opportunity to share these research findings with this urban high school community and beyond.

A goal for future researchers would be to replicate this study on classroom questioning within other special education mathematics classes. Likewise, future studies would address gains in motivation and self-confidence within inquiry classes across a range of applicability. This valid study could be constructed within different schools and grades as well as within different content areas. Varied ability-levels could also be addressed. The vision, for future action research studies which replicate this project, would include trained, spirited questioners who further the the scope of inquiry with faithfulness and validity in the search of authentic student self-confidence and motivation.

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Chalk Talk Protocol

The Coalition of Essential Schools' Chalk Talk

Adapted by Christina Stohl, C.A.G.S.
Special Education Self-Contained/Inclusive Classroom 9-12
September 28, 2009 and Night of Excellence December 3, 2009

STUDENTS' ATTITUDES TOWARDS MATHEMATICS

USE A BLACKBOARD OR LARGE PIECES OF BUTCHER PAPER PASTED TO THE WALL TO ELICIT A STUDENT-RUN SILENT WRITTEN DIALOGUE ABOUT THEIR FEELINGS AND ATTITUDES TOWARDS MATHEMATICS.

THIS IS AN INTERDISCIPLINARY, MULTIPLE INTELLIGENCES, AND INQUIRY ACTIVITY.

The teacher/facilitator writes on the butcher paper the following question:

HOW DO I FEEL ABOUT MATHEMATICS?

Students stand in a semi-circle around the butcher paper, holding an individually colored marker. First the students sign their names. This signature in a specific color identifies their written thoughts for later discussions. Students should think about what thoughts they have about mathematics structures, issues and challenges as well as explore their own purposes and motivations, along with their wants and needs. THIS IS A SILENT ACTIVITY. It urges thoughtful contemplation and self-assessment.

- Any person can write an idea or question on the paper.
- When others have read what is written, they, too, may attach their ideas, either connecting or contrasting.
- One after another, individuals should feel free to add their ideas to the growing dialogue, connecting their ideas to others with lines or arrows.
- After the flow of ideas has abated, students stand back and try to "read" the whole display to make sense of what is there.

When this activity is over, the whole group may discuss the comments and questions suggested about the process of understanding personalized mathematics learning. This Chalk Talk Protocol was conducted on September 28, 2009 and was repeated for contrast before the Night of Excellence. Both Chalk Talks were displayed for the consideration of all.

PRACTICAL USES FOR CHALK TALK

- Assessing prior knowledge
- Assessing what was learned
- Discussing difficult issues
- Solving problems
- Recording what was discussed
- Communicating to others through silence and through writing

Notes