Managing Student-guided Inquiry How can we use student questions to drive instruction more frequently or with greater skill? Which methods work best in supporting a student-guided inquiry approach?

Jessica Pepe-Roethel
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Which methods work best in supporting a student-guided inquiry approach?

Jessica Pepe-Roethel
Saint John Fisher College
Graduate Math/Science/Technology Department
Student-guided inquiry

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Chapter 1 - Introduction

According to the American Association for the Advancement of Science's Project 2061 Benchmarks, "from their very first day in school, students should be actively engaged...this means encouraging them to ask questions and to seek answers. Student investigations ought to constitute a significant part...of the science experience" (p.13). It is not only important in my classroom, but in science classes in general, that we learn how to use student questions to drive the scientific process.

During my seven years of teaching I have found eighth grade students to be curious, inquisitive, active participants in science, who when given the opportunity to explore, always share great questions. When I started teaching, if students asked questions, I answered them. As I progressed through the Math/Science/Technology graduate program and became a more experienced teacher, I began to think more and more about the level of student involvement that I had in my class, and how we could answer their questions differently.

I started posting student questions in my classroom at the end of my first year of teaching. I offered students the opportunity to answer the questions for extra credit outside of class, but few did. I found myself busied by class activities, and often forgot to answer or discuss their questions in a timely manner. I was devaluing their questions without intending to. Later, I attended a conference where the speaker discussed an approach she used to allow students to design their own investigations. She set aside every Friday for students to investigate their questions, and called them "What if? Fridays". I implemented her idea that year, and my students provided positive feedback at the end of that school year regarding their Friday investigation days. I felt the need the following year to structure the Friday investigation days for students to ensure the acquisition of understandings of the benchmarks, so I started the next year by
assigning questions to interest groups. Although all questions were still not being answered, many were, so that format worked considerably well.

The approach that I have used in my classroom, including posting student questions and working toward completely student-guided inquiry, has evolved over the years. My interest lies in forming a better understanding of how to develop student questions into centerpieces of ongoing classroom inquiry more effectively. I chose as my initial tool a list of student questions, around which students would develop their own investigations.

This research aimed to identify specific methods and strategies that effectively and efficiently support student-guided inquiry to make learning more student-driven and authentic in my classroom. It grew into an inward search and personal assessment of my current construct of inquiry, depth of understandings and personal success.
Student-guided inquiry

Chapter 2 - Literature Review

Introduction

In only the past few decades, our understanding of how students learn has changed dramatically. We have progressed from the old paradigm popularized by John Locke, that the untrained student mind is regarded as an empty vessel that gets filled by the teacher. Educators now understand that students construct their own knowledge by making connections between what they already know and what they are learning, through investigation and discourse (Piaget, 1960; Rogers, 1982). Students are no longer considered to be receptacles for knowledge, nor are teachers considered the sole purveyors of that knowledge.

The science and education communities agree that investigation is a decidedly effective way to teach science. Thus, students build their understanding of science and investigative skills through inquiry, connecting their previous knowledge with new ideas and evidence. (National Research Council [NRC], 1996; American Association for the Advancement of Science [AAAS], 1993; National Council of Teachers of Mathematics [NCTM], 1991). In practice, educators have found that using inquiry increases the depth of student understanding and interest in science (Drayton & Falk, 2002). Students are more excited about science when they are actively involved with it than when they are passively involved, and find meaning and relevance when they can associate with it. Educators recognize that students learn best from having personal experiences with the content and connecting it to information they already know.
In an effort to improve educational results, new standards in science education call for teaching methods that require the learner to be a part of an inquiry process through which they can share ideas and search for answers to their questions (NRC, 1996; AAAS, 1993; NCTM, 1991). Though inquiry learning is effective for students, no single teaching method is appropriate in all situations, for all students. Inquiry-based teaching and learning occurs on a continuum, depending on the instructional goals and student needs (Haury, D, 1993).

If we are to incorporate student questions and the inquiry process in the classroom with increased frequency, we must examine what inquiry is, why we use it, and implications in the classroom for the teacher and student.

Inquiry defined

Inquiry is not as basic as it might be conceived in the traditional sense, as a step-by-step process that solves a problem, but is a "subtle, flexible and demanding process" (p. 221), states the Benchmarks for Scientific Literacy (AAAS, 1993). It takes skill on behalf of the student and teacher in order to be implemented effectively. In the publication, Inquiry strategies for mathematics and science: It's just good teaching, Denise Jarrett cites scientist Alfred Novak’s definition of inquiry, “The [set] of behaviors involved in the struggle of human beings for reasonable explanations of the phenomena about which they are curious” (p. 31). Educators have the task of inspiring students; by providing experiences with the content that make them interested and feel safe enough to ask questions and make mistakes.

Implementing inquiry learning in the classroom starts with identifying learning goals and providing students with opportunities to ask questions about phenomena related to the goals, and
Student-guided inquiry time to develop and carry out courses of action to test their ideas (Cutter, Magnusson, Palinscar & Vincent, 2002). Students need time to make hypotheses, design and carry out investigations, connect their results with the content, and especially to go back and reflect upon their results, errors and plan future studies.

Inquiry can occur along a scale or continuum, from being driven mostly by the teacher to almost completely student-directed. At one end of the continuum is structured inquiry, where students are engaged in a hands-on activity that is completely planned by the teacher. Structured inquiry is an appropriate method to use at times, because it focuses students on a part of the process, such as data collection or analysis. It provides the student with more modeling and support than a less structured inquiry task. In structured inquiry there is a specific end point or product. In the middle is guided inquiry, where students may decide on the procedure for the investigation, but the teacher chooses the question to be explored. The purpose of guided inquiry is to allow the student more responsibility for thinking and doing while still allowing the teacher to facilitate and model certain aspects of the investigation. Student-guided inquiry, sometimes called student-initiated, open or full inquiry, in which students generate their own questions from a topic selected by the teacher and design their own investigations, is at the opposite end of the continuum. It provides opportunities for the student to solve problems that are of personal significance. The teacher identifies the learning goals and guides students, allowing them to work through the problems as independently as possible (Martin-Hansen, 2002). Student-initiated inquiry allows student the opportunity to investigate questions that are personally or socially relevant. The National Research Council states, "Inquiry into authentic questions generated from student experiences is the central strategy for teaching science" (NRC, 1996, p
Student-guided inquiry

31). Therefore, student initiated inquiry should be the driving force behind a considerable amount of science instruction.

Rationale: Why we use the inquiry process

Student minds were once viewed as empty vessels into which instructors poured their knowledge and wisdom. Students were considered passive recipients of knowledge and the faculty members were considered owners the knowledge (Johnson, Johnson, & Smith, 1991). As a result of brain and education research and our understanding of the cognitive learning theory, we know that students do not passively accept knowledge from the instructor or curriculum. They activate their existing cognitive structures or construct new ones as they process and make sense of new information (Haury, 1993).

A major motivating force for human beings is their need to make sense of their world (Sutton, 1984). We know from brain research that relevance, or meaning, occurs on a cellular level. "An already existing neuron simply "connects" with a nearby neuron. If the content is irrelevant, it's unlikely a connection will be made" (Jensen, p. 92). Since classroom information often lacks the personal connection that will create meaning, we can help students make those cellular connections by framing their discourse, using personal stories, and talking and sharing with one another. This will engage the learner and make the classroom information more relevant.

Vygotsky's well known concept, the Zone of Proximal Development supports these ideas. Since we are "biologically wired for language and communicate with one another" (Jensen, p. 93), we must provide students with opportunities to reach their maximum levels of
Student-guided inquiry performance, or maximum assisted performance, through collaboration with the teacher and peers (Newman & Holzman, 1993). It is of critical importance that the teacher helps the student construct meaning when it does not emerge on its own.

In addition to making learning meaningful for students, inquiry-oriented instruction can lead to rich outcomes of student performance and behavior. The National Science Standards envision students who are able to know and understand the complexity of the world around them, use scientific processes and principles when making decisions, engage in discussion and debate about technological and scientific issues, and have the knowledge, understanding and skills of a scientifically literate person (NRC, 1996). It is logical for teachers to support the use of inquiry if we are to expect students to achieve these outcomes.

By using student questions as a starting point for instruction, a classroom begins to take shape with a culture of ownership and engagement. Teaching students to ask and answer questions, that their questions are valued, and that teachers do not have all of the answers is the cornerstone of scientific inquiry. Further, methods that ensure that teachers can help students understand all of the content required by the course curriculum are explored.

**Considerations: Implications for the teacher and student**

There are important considerations to be made by the teacher when implementing an inquiry-oriented program. Successful implementation of the inquiry process requires a variety of methods that a teacher must choose according to the goals. Inquiry takes time. It can reinforce misconceptions. It requires a different type of classroom management than many teachers have experience with or are comfortable with. It can lead to errant learning, and it can often leave
A review of the literature can lead an inexperienced teacher to believe that hands-on investigations are the only acceptable or appropriate method to teach science content so that students can construct meaning. The literature on inquiry has placed tremendous emphasis on the need for inquiry-oriented instruction, but does not always clearly identify methods other than laboratory-type hands-on activities, that teachers can use to help students create meaning. Teachers must have a command of various approaches such as the learning cycle method of lesson development, use of classroom discourse and questioning, and activities using appropriate text (Baker, Lang & Lawson, 2002).

A variety of instructional methods should be used, including direct instruction, since not all science can be learned through inquiry (Hinman, R.L., 1998). Since some science content, especially in the upper grades, is more effectively taught and learned through lecture, text, presentations or other traditional methods. It is up to the teacher to decide the appropriate time for inquiry-based activities and explicit, direct explanations.

Learning experiences must include the designing, carrying out, analyzing and discussing of experiment results and their connections with the content (Baker, Lang & Lawson, 2002). It is also important to consider that active science does not always include a laboratory investigation. Students are also active when they are constructing their own knowledge during activities such as lecture, classroom discussions, journal writing and reading. The teacher must provide students with a variety of experiences and levels of activity to meet the goals of instruction.
Student-guided inquiry

The inquiry process is time consuming. Full inquiry is a complex process. It can increase depth of meaning, but can also decrease the amount of content covered within that time period. For teachers with science classes of short duration or who are worried about covering content, this can be problematic. It is important to recognize that the inquiry process can become disjointed by a disruption of the process due to short class meetings, so the teacher must be skilled at helping students connect their prior experiences with the activities they are working on each day. Buttemer and Windschitl (2000), two university professors said “no meaningful inquiry can take place in a fifty-minute period, perhaps not in a week of class time. Students can move from novice to expert inquirers only through repeated, teacher supported inquiry opportunities throughout the year” (p.350). In short, the time commitment that inquiry requires is a considerable hurdle to many teachers. Surprisingly, the literature consistently lacks clear and simple methods for teachers to employ that make inquiry manageable within time constraints.

Mistakes in data collection can quickly convince students that their misconceptions are correct. It takes time for a student to redo an investigation and collect data again, and sometimes the initial reinforcement of their misconceptions through data collection makes it almost impossible to convince students that they made an error. In their minds, the data made sense because it supported their ideas. This can lead to errant learning. Weak students are especially vulnerable (Holliday, W.G., 2001). In this case students may simply memorize the concept for a brief period of time but never actually make sense of the experience. Students and teachers have to understand that making mistakes is an important part of the process, not a waste of time. This is a critical point, especially considering increased pressure on teachers and students to cover a great deal of content and perform at the mastery level on state and standardized assessments. The process has to undo the misconceptions that it reinforced. Therefore, we must be sure that
students have a rich understanding of the various tools that they can use to organize and analyze data, such as graphs, visuals and graphic organizers (Buttemer & Windschitl, 2000).

**Why use their questions?**

If the student is to have ownership of an investigation, perhaps she should help define the question being investigated. On this topic, Saul (1996) states,

I have worked with smart, scientifically skilled people designing curriculum for children. Invariably they begin with their own excitement about a given problem, ask fascinating questions about the concept or material in question, and then create a series of activities that help answer their questions. The problem is, of course, that they are working with their questions. They don't trust children to have questions of their own, and they don't trust themselves to build on student questions in a creative way. (p. 9)

Mestre and Lochhead (1990) likewise focus on students' questions in the following:

Students should be encouraged to ask, as well as answer, questions. Also, students should be helped to distinguish between those questions that can be meaningfully posed and answered within science, and those other nonscientific questions that are outside the purview of science. In addition, students should be taught the art of formulating scientific questions, breaking up "large" questions into more manageable "smaller" questions, and designing a procedure (whether involving experimental work, library research, or other means) for answering them. (p. 62)
Children's ideas are windows on their existing knowledge, and are thus foundational to a constructivist teacher. Wynne Harlen (1996) points to the significance of children's questions as well. Harlen proposes that teachers categorize questions into those that are investigatable, and those that are not, and work to turn children's questions into the bases for investigations. She writes,

'Turning' questions into investigatable ones is an important skill since it enables teachers to treat difficult questions seriously but without providing answers beyond children's understanding. It also indicates to children that they can go a long way to finding answers through their own investigation, thus underlining the implicit messages about the nature of scientific activity and their ability to answer questions by 'asking the objects'. (p. 112)

If students can indeed gain confidence in their ability to investigate, in their own ability to pose and answer their questions, they will have gained some very real power. People do not simply "discover" how to work like scientists, however, simply through unguided experience. Driver notes that “Science ideas, which are constructed and transmitted through the culture and social institutions of science, will not be discovered by individual learners through empirical enquiry: learning science involves being initiated into the culture of science (p. 6).”

Conclusions

The articles reviewed for this paper suggest that the teacher and student are partners in the learning process, and that inquiry-based approaches should drive instruction in the science classroom (NRC, 1996; AAAS, 1993; NCTM, 1991). Since the inquiry process is time consuming, requires significant classroom management skills, and can lead to inaccurate
Student-guided inquiry understandings if it is not structured appropriately, the teacher must organize the course carefully and employ a variety of methods to ensure that students are making sense of the content.

Constructivist theory places the experience of the learner at the center, with social relationships between learners and teachers playing a significant role. Critical theorists also focus on this relationship, calling for an active dialogue between teacher and learner. Science inquiry instruction based on student questions offers an avenue for the development of this dialogue, and allows students to build their skills in investigating the natural world with the support of their teacher. Using student questions makes learning activities more meaningful to students. My research will explore the student-guided inquiry model of science instruction, with the emphasis on the use of students' questions, and how to manage them.
Chapter 3- Methodology

Background

My methods draw together critical reflection, embodied in my journal, and student results, as evidences of student work and in conversations we will call interviews. The activities developed during this study allowed students to investigate their questions regarding a topic of study, discuss their conjectures, collect and report on their data, and apply their findings to the concepts they were responsible for learning. All students were given a list of benchmarks (Appendix A) or required learnings as they completed their investigations. Some lessons were completely student driven, some were a partnership between students and the teacher, and others were teacher led. All activities, however, were centered on student questions as my classroom activities usually are. Student-initiated, guided and structured inquiry activities based around student questions were used during a two-week study of energy, specifically renewable and nonrenewable energy sources and fossil fuels. See Appendix A for an outline of activities and data collection methods.

This chapter will describe the participants and their learning environment, data collection methods and procedures.

Participants

Twenty-three eighth grade science students at Thomas C. Armstrong Middle School in the Wayne Central School District in Ontario, New York were a part of this study. There are twelve Caucasian females, two African-American females and nine Caucasian males in the class that range in age from 12-14. Student abilities in this class are varied. They scored anywhere from the below average to mastery range of the Terra Nova standardized tests last year. These students ask questions frequently and are generally interested in science. They were chosen
Student-guided inquiry because their class has the greatest range in ability as measured by their standardized test results, compared to other classes that are more heterogeneously grouped. Some are very motivated and high-achieving, while others are less involved. All students, however, show an interest in science when they are involved in the activities in class, and all passed the course mid-term assessment and the New York State Intermediate Level Science Performance Test Part D.

The physical environment is a traditional lab set-up. There are twenty-five student desks in the middle of the room, three tables that are used as workstations, a teacher lab workstation, two student computers and lab counters and supply drawers around the perimeter. Student desks and chairs are not fixed, which allows students to move desks into different configurations. There is enough counter space for all students to work safely on laboratory investigations. Hundreds of text resources fill a bookcase in the classroom, and an abundance of physics and chemistry laboratory materials are organized in an adjoining storeroom and in the basement. Most materials that students might need are at hand in the adjoining storeroom. Students are aware that there are supplies available for their use if they ask permission.

The culture of the class is very positive, structured and comfortable. Students are in class for forty minutes a day five days per week, during which they have a daily routine, which involves doing a warm up activity, discussing the previous day’s objectives and a completing a learning activity. The class routinely meets within the last five minutes for closure. Homework assignments are always linked to class investigations.

Data collection methods and procedures

I used several methods to collect data for two weeks during classroom inquiry investigations, including field notes, a reflective journal, student work, and student interviews.
Field notes were written in a notebook during class investigations. The goal of the field notes was to capture the essence of the investigations in class, especially student interactions, questions and discussions, methods used to test hypotheses, content emphasis and ideas shared at the end of each investigation. The field notes affirmed my journal conjectures.

The teacher's reflective journal recorded perspectives about each day's investigations and the inquiry process. It served as a tool to record how to monitor and adjust the classroom activities. It recorded the analysis of the effectiveness of the different approaches being used in the classroom. The journal helped the shape future learning activities, and recorded perspectives and impressions that I had regarding the inquiry approaches. In the end, coding my journal led me to see that my research questions evolved from lack of confidence or a limited recognition on my part of my levels of understanding of inquiry instruction.

Students recorded their questions, hypotheses, procedures, diagrams, data, conclusions, models, concept maps and notes in their notebooks. Students were required to explain and defend their conjectures. They wrote down each benchmark or objective that was met at the end of each investigation in red pen, and were required to explain how their investigations apply to those objectives. They took a two-part test (Appendix C contains part 1, Appendixes D and E contain part 2) and submitted a mini-project (Appendix F). Interviews were conducted informally and were audio taped for transcription purposes.

Reviews of the literature identified ways that student questions could be used to encourage inquiry in the classroom. I focused data collection on how student questions were managed, how learning related to those questions, and how I perceived things. Since I wanted to investigate how to use the student's questions to drive instruction, it was most logical to allow
Student-guided inquiry
the data or the activities and behaviors in the classroom dictate the direction of data collection.

Student success, as evident in the collected data, supported my results.

In the next section, I will present my conclusions following the analysis of my journal entries, student results and interviews. My reflections became the most interesting part of my inquiry; a lens through which we will view the student-guided inquiry process and my regard of their and my respective success.
Data Gathering (beginning)

I introduced the unit with an anticipatory set, followed by the introduction of a project during which they had to research and investigate via labs. Students participated in a two-week partner project, within which instruction and laboratory activities were embedded. Field notes taken during class, focused on what students were doing. This allowed me to compare how students were interacting and performing in class compared to how I thought they should perform. I recorded my perceptions in my journal.

Data Analysis (middle)

After students completed their first few journal entries and a short test, I looked at their responses compared to the benchmarks. They performed quite well. I was feeling proud of their performance. I read a few student journals, then read my own. I started to see that this research really was focusing more on my reflective practice that the use of student questions in my classroom. The more I read, the more my understandings were confirmed, and the less focused I became on what I was not doing correctly regarding using inquiry and student questions and the more focused I became on effective elements of instruction and my own confidence.

Data Gathering (end)

As the second half of this short unit commenced, I focused more on my journal and field notes, and asked students informal questions. I was looking for changes in how I was perceiving my classroom and my teaching.

Introducing the topic

On the first day of this unit, as with all other unit introductions, I did an anticipatory activity with the students. I arranged the desks that day in small groups. Students were handed a
Ziploc baggie and a latex glove as they entered. I asked one group at a time to come up and reach into a paper bag. They found that the bag was filled with gummi bears. Most grabbed a big handful. As more students grabbed from the bag, we started to discuss how many gummi bears were left. Students had different opinions about how many they should take. We discussed how some students felt since they did not get any, and how others felt having gone first and taken a lot. I told the students that the candies represented fossil fuels, and asked them to discuss what the activity was all about. Once we agreed about the definition of fossil fuels, I challenged students with some open-ended questions about their use of fossil fuels. They worked in small groups and generated part of a KWL chart (Appendix G): what they think they know, and what they want to know. We posted the charts and I asked students to expand on their ideas that night for homework.

Student reflection:

While doing the gummy bear activity today I learned that the gummy bears in the bag are like fossil fuels. If we take all of them now, they are going to run out. The difference is we can’t make more fossil fuels right now like the factories can make gummy bears. I am just wondering if the earth is ever going to make more fossils. Like how can it make fossils if there’s no rocks on top of the dying stuff now. Maybe we will run out of the fossil fuels we dug into the crust of the earth to get, or maybe the earth will make more, new fossil fuels before then. So my question is how long will it be until we make more fossil fuels?

Julie was asking questions that were recorded and classified by her group.
Student reflection: Matt, Day 1

Coming up with the questions was hard because I didn’t get what fossil fuels are. But now I know that they are coal, oil and natural gas because my group found the answer. When the people with my group started to give their questions, it made me think of some questions like why don’t we use solar power? The sun is free and it shines a lot. Why do we pay all that money for oil and stuff?

These questions were refined in class within the student’s small groups. They reworded them to ask, Will our supply of fossil fuels run out? How long does it take to make fossil fuels? Why don’t more people use solar power to heat their homes? Why don’t we use solar powered cars? The groups decided that some of these questions could be answered by researching on the Internet. They found out a couple of answers that day in class and added them to their KWL charts first in small groups, and then as a whole class.

These journal entries are a perfect example of the fundamentals of inquiry in my literature review. They demonstrate student thinking that leads to inquiry-based investigations.

Teacher Journal, Day 1

I have used this method of providing an event that helps students think about the things that they are curious about consistently for a couple of years. I looked back today into my plan book and I’ve been using this method more than I thought. It provides a safe method for students to discuss what they are wondering. It works well. Every student in class participated in their groups. Students reflected. Everyone posed at least 3 questions and had ideas of how to address them. I am wondering if they will all be motivated to look for answers since this is a hard topic for which to find hands-on
investigations that relate specifically to the benchmarks. I can’t really find anything in the articles that I found—no profound ideas. I’m sure there are people out there that have some better approaches than this one—seems simple.

* Check articles—any new ideas? Other better ways to get them thinking that are new?

I coded this first entry later and found that there were perceptions of success and failure emerging consistently.

The Process: Classifying and addressing their questions

Students classified their questions during the second day. At first, students classified by topic or type of energy: oil, heating houses, coal, etc. They needed to be challenged to consider that they could also classify questions by how the answers can be found or whether or not they could test out the answers. As groups realized that they could classify their answers differently, more questions emerged.

Teacher: How did your group decide to classify your questions?
Jen: Well, we put them into groups, like coal mining, cars, and oil.

Teacher: Great. Did your group discuss any other ways to group them?
Jen: Yeah, like maybe when they will run out or if they will run out.

Teacher: I see. How will you find those answers?
Jen: I don’t know.

Teacher: Okay, why don’t you discuss that within your group and call me back when you have some ideas.
Student-guided inquiry

Jen called me back over to her group and she said that they decided that they could find a coal mine or museum and e-mail them, or they could look it up in a book or they could do an experiment to see what happens with oil.

Teacher: So what are your methods for data collection.

Jen: (pause) Um..mm I guess looking things up, e-mailing people or doing labs.

Teacher: Great! So what did you find?

Chad: That we can group them by topics or by how to find the answers.

The class had just identified different ways to manage the questions, either in interest groups, or by method. As a class, students chose to go by interests since they thought it would be unfair that some would do labs and others would do research. They looked at their research, although it was regarding their own questions, as less engaging than activities would be. This is occasionally supported by the literature, which could lead some teachers to believe that laboratory activities are always more engaging when they are driven by student questions, which is not always the case. Sometimes students do not naturally value the questions their classmates have.

Assessing Student Performance

Test Results

After seven days, students had been exposed to and tested on seven benchmarks or key understandings. They were assessed by a three-part test, modeled after the NYS Intermediate Level Science Test. Part A consisted of eight multiple choice questions, Part B of three constructed response questions, and Part C of an extended constructed response question. 100%
Student-guided inquiry of students scored in the passing range, 78% in the mastery range (87-100%) and 22% scored between 65% and 86%. This is in line with their usual performance, as students normally score within the 72%-79% mastery range.

Project Assessment

Most students chose the poster option of the project instead of other options, such as writing a poem, making a commercial or a song. I was unable to be in the classroom the day the project got introduced, so I think that the lack of modeling lead to the lack of varied choices. All students, however, did meet the minimum project requirements, which were an in-depth analysis of benchmarks related to their topic choice. Six students needed to make revisions. Following revisions, all benchmarks were achieved by all students.

Journal Coding

When I coded my journal, I found several elements that frequently emerged, including feelings of success, feelings of self-doubt, and realizing that I understand inquiry. These were more apparent than any other theme. In fourteen days, I coded 5 feelings of success, 17 feelings of self-doubt/looking to the experts, and 21 realizing that I understand inquiry. After the first week, I recognized that there was an underlying problem with my own view of my teaching and success, and a discrepancy between my perception of my understanding of inquiry and my actual level of understanding.
Chapter 5 - Discussion

Summary of results based on research question

How can we use student questions to drive instruction more frequently or with greater skill?

In the past, I have always viewed student-guided inquiry as a long-term, extensive task. I never thought my classroom was as student-driven as it should have been. When I considered posting student questions and tried to address all of them, I felt bogged down because I felt obligated to take weeks or even months of class time to cover all of the pieces of content. I would plan intense, time-consuming yet rich investigations, and did not give enough value to strategies that would take less time but give students ownership, time to construct their own meaning and achieve higher-order thinking. I disregarded the smaller inquiries that I provided to my students, although I used them often, I viewed them as not being effective enough. Because I devalued them, because I perceived myself as teaching less effectively than I should be, I think my teaching was affected.

Within my journal, I find data to support the frequency and the skill with which my classroom is run via inquiry. I cite fourteen different ways that I use student questions to drive instruction throughout a two-week investigation. These are methods that I use with frequency during the school year. I use the "Question Board", a place where student questions are posted, referred to daily, and through which journal activities, homework assignments and daily "warm up" questions revolve, and I have a general philosophy and approach that is naturally inquiry-driven. I found no revelations in the literature to change my current understandings.

Which methods work best in supporting a student-guided inquiry approach?
Student-guided inquiry

I have identified methods that I currently employ that help my classroom function effectively under an inquiry umbrella. These include best practices such as

- encouraging discourse
- anticipatory activities
- discrepant events
- list/classify questions
- construct meaning
- think-pair-share
- design labs
- design assignments around questions related to benchmarks
- using authentic text
- using different technology
- thought provoking problems
- learning cycle
- scientific method
- compare/contrast concepts

Taking the time to recognize and identify these methods which I currently employ successfully has indirectly improved my practice because with an increase in confidence I feel like I have become a better teacher.

Interpretation of Results

I began with a desire to identify specific methods and strategies to support open-ended, student-guided inquiry in my classroom within time constraints. I was looking for some answers, revelations, newfound ideas or strategies that would inform my practice and make my teaching, especially the use of student questions more effective. I figured that if I took some time to pore over the literature, reflect and self-assess, some specific, tangible methods or approaches would become apparent.

I read every book and article I could find centered on inquiry, constructivism and student questions, including those from past graduate courses in inquiry, problem-based learning and assessment. I revisited publications that I found useful in the past. I read hundreds of articles and
Student-guided inquiry a number of books. I joined an online collaborative research group of six teachers investigating the inquiry processes in their classrooms. I kept searching for the profound publication, the ultimate practice, strategy or approach that could finally change the way I teach using inquiry or significantly improve my teaching. Everything I read, however, supported my current understandings, and helped me to reflect upon what I was currently doing and doing well. I assumed that if I was already practicing what I found, I must be missing some part of the big picture out there, that defines inquiry differently or approaches it with more depth than I had. Surely the experts or more experienced practitioners would have some insight that I had not considered that would increase the effectiveness of my inquiry program. I came to my advisor four times to ask if there was some body of literature out there that I was not finding that would better inform my practice.

What emerged from this research was something completely different than I ever would have anticipated. While I know that I still have a lot to learn about teaching, I have not found new methods or specific strategies to improve the inquiries in my classroom. I began to look inside, and address a much bigger issue than that of how to address student questions and use them more frequently or with more skill. I discovered that the answer that I was looking for lied not with what the experts say, but with the experience that I had with inquiry. I questioned why the experts didn’t have the answers I was looking for and discovered that I knew more than I gave myself credit for. I had a fundamental understanding of inquiry that is much better developed than I had accepted or recognized.

I experience a lot of self-doubt and a lack of confidence in my proficiencies in using inquiry approaches and methods. My colleagues always tell me that I am my own worst critic, which I regard as a compliment, because I certainly cannot profess to be an expert on anything
Student-guided inquiry related to teaching, since it is such a complex profession and an art. Over the years, I have become my own critical friend, and the lack of discourse between my coworkers and myself has resulted in my own cognitive dissonance regarding my proficiency.

Some soul searching, analysis and reflection has led me to the realization that my approach to the curriculum was already quite focused on student ideas and questions. I already judge the effectiveness of my approach on student responses to it, as well as their accomplishments and demonstrated learning, with a very critical lens. This has resulted in a very student-centered classroom. In the past I have viewed the struggles that I have had structuring the classroom activities around student questions as failures, when all along I was constructing my own understanding of what inquiry is as my students were a part of the inquiry process. The students and I were both experiencing cognitive dissonance; they with the content, and me with the teaching of the content. I began to wonder if my internal conflicts, regardless of how healthy, were similar to theirs, and whether or not that was affecting their learning and progress as it may have affected mine.

I had struggled with questions such as whether or not what I was doing was "right" or most effective, or if I was skilled at inquiry methods. I needed to read every publication I could find regarding inquiry to finally convince myself that my approaches are effective, and that inquiries in my class looked very different depending on the time or the content.

Insights

In the course of my own investigation my definition of inquiry was challenged, as were my ideas of what makes it successful in my classroom. While maintaining a focus on student questions, I was able to gain new insights from a model of student-guided inquiry that was less time-intensive than the models of extended-inquiry that I had used in the past. Perhaps the
Student-guided inquiry greatest benefit that evolved from my research and reflections was the affirmation that I have already implemented strategies that are effective, that the experts agree with those strategies, that implementing short-term, open-inquiry can result in student success, and that student-guided inquiry can be manageable and make students achieve in-depth understandings. It has also led me to investigate options for my own personal and career growth.

I began this project with a focus on my “Student Question Board”, a specific location where I recorded student questions. I wanted to find an inquiry “expert” through my study of the literature that would teach me some best practices to use to address the questions that we post in the classroom. I found out about half way through this study that I just needed to read and watch what my students were doing more intensively and to reflect upon their successes. I had failed to recognize the success of my approaches and the level of proficiency that I had in inquiry methods and understandings. My research evolved from being a search to find answers hidden in student work to a search to find answers within myself.

I have concluded that inquiry is a state of mind, an attitude, a general approach to teaching. It’s not embodied in the specific methodology, the best single structure, the few sole approaches, or the one way to set up the physical environment of the classroom that makes it work; which is what I originally hoped to find through my study. It is formulated in best practices, good teaching, and an attitude that understands and values students, encourages thinking, that is flexible and driven by a marriage between student interest and course requirements.

Recommendations for further research

As this study began, I viewed fast-acting approaches to student-guided inquiry as less effective than full-blown, open-ended, student-guided inquiries, which I don’t think is at all true.
Student-guided inquiry now. I think it would be interesting to find out how other teachers view inquiry. If it took me several months and the experience of reading everything I could find in the literature regarding inquiry to finally recognize that I did know what inquiry was and that I was already successfully implementing it in my classroom, I wonder how new teachers or teachers in the Inquiry class at St. John Fisher would perceive different levels of inquiry. I would be interested in a study of videotapes of teaching similar to that from the GMST 500 course. In that course, teachers implement a lesson and videotape it, and then are given a rubric to measure their proficiencies in inquiry teaching. A study could involve a small group of teachers, perhaps a department group. They could watch the video and assess the level of inquiry at which the teacher is functioning. I hypothesize that even experienced teachers would perceive inquiry methods very differently. I would be interested in facilitating discussions to see how people define inquiry.

This also brings to mind the question of whether or not teachers take the time to reflect on and process what they value. I have always put great value on student questions and I consider myself a reflective person, yet I have never spent an extensive amount of time investigating that interest. I am curious about whether teachers in different school districts are given time as a part of their professional development to research and reflect, or whether it is valued at all or is evident in discussions between teachers and administrators.
Appendix A

ENERGY AND FOSSIL FUELS UNIT BENCHMARKS

You are responsible for meeting the following learning goals by ___________

1. Identify the sun as a major source of energy for earth, and other natural sources as nuclear and geothermal.

2. Describe the following natural energy sources: solar, nuclear, geothermal.

3. Define and describe renewable and non-renewable energy resources.

4. Identify and define fossil fuels: non-renewable resources which contain stored solar energy.

5. Identify fossil fuels as a major source of energy for the US.

6. Describe the following non-renewable energy resources: solar energy, wind, moving water, bio-mass.

7. Identify alternatives to using fossil fuels.
Appendix B

Activities and Data Collection Methods

Bold-faced items are data sources.

Day 1: anticipatory activity: gummi bears as fossil fuels
Objective: articulate that fossil fuels are finite, develop list of student questions, add to KWL chart, teacher journal entry #1

Day 2: share questions with whole class, refine and classify in groups of 3
Objective: to determine what we want to know on KWL chart and generate ideas, students write down their how to find answers, teacher journal entry #2

Day 3-5: mini-projects: using text and Internet resources, identify questions to Investigate. Prepare an individual report, poster, poem, etc. Embedded instruction in small groups so that all groups have had instruction around preliminary goals by day 5, teacher journal entry #3-5.

Day 6: Project share.
Objective: to achieve unit goals through the sharing of information found, teacher journal entry #6

Day 7: test on unit goals, teacher journal entry #7

Day 8: provide students with item analysis of test #1. discuss results.
Objective: students record what they learned on their KWL charts, and how they relate to unit goals. Students have a dialog about their results and record what they need to know in a short paragraph, teacher journal entry #8

Day 9: as a class and in small groups, we refine, and reclassify the questions that are still unanswered.
Objective: to revisit KWL chart, and write down how we will find answers, teacher journal entry #9

Day 10-11: Class breaks up into small groups to investigate questions, teacher journal entry #10-11

Day 12: Pair and share with the whole class: What have we learned? Revisit KWL chart, teacher journal entry #12

Day 13-14: Complete notebook records including KWL chart and connections with content, teacher journal entry #13-14

Day 14: project submission, teacher journal entry #15
Appendix C

Fossil Fuels/Energy Test

Name ___________________________ Date ________________ Class ______________

Directions:
For questions 1-10 choose the best answer. Answer in the test booklet first, then transfer your answers to the scantron form. No grade adjustments will be made due to errors on the scantron, so be sure to erase thoroughly.

1. Examples of fossil fuels are
   1. nuclear, oil, gasoline
   2. coal, nuclear, solar
   3. coal, oil, natural gas
   4. wind, solar, geothermal
   5. ________________________________

2. Which of the following statements are TRUE?
   1. fossil fuels are finite
   2. fossil fuels took thousands of years to form
   3. we use alternatives to fossil fuels more than we use fossil fuels
   4. the cost of oil is currently decreasing

For questions 3-6, match the type of energy on the right with the definitions on the left. You will not use all of the choices on the right.

3. energy that is transferred from the sun
   1. GEOTHERMAL

4. energy that is stored in the nucleus of an atom such as Uranium or Plutonium
   2. BIOMASS

5. heat energy from the earth
   3. NUCLEAR

6. energy from plant matter
   4. HYDROELECTRIC

7. Petroleum comes from
   5. SOLAR
   1. crude oil
   2. gasoline
   3. coal
   4. iron

8. A graph shows the sources of energy in the United States. What do you conclude?
   1. The United States relies most on non-renewable resources.
   2. The United States uses enough alternative energy to meet its needs.
   3. The United States exports a lot of petroleum.
   4. Petroleum and coal are the most abundant elements in the United States.

9. Petroleum products are used to produce
   1. elements
   2. plastic
   3. lower temperatures
   4. higher densities

10. Alternatives to fossil fuels are
    1. renewable
    2. non-renewable
    3. currently cheaper to use
    4. being used more than fossil fuels in every country other than the US
1. What are the similarities and differences between using fossil fuels and energy alternatives? Use the Venn diagram below to record your ideas, and then explain what you organized in the Venn diagram into a paragraph below it. Be sure to define fossil fuels, identify several alternatives, tell how they can be obtained, and the benefits and disadvantages of using them, and compare how we are currently using them.
Appendix E

Fossil Fuels Test Part 2 Continued

2. Some people think the United States should not worry about the possibility of losing our oil supply from Iraq and the decrease in oil from Venezuela. Use the information below and your knowledge of the topic to explain what you think. Should we start to invest in alternatives? Should we simply rely on other countries to supply more of our oil? If we invest in alternatives or rely on other countries more, what are the benefits and disadvantages?

3. In this box, list as many examples as you can of products that come from petroleum. The more you list, the better.
Energy Project Requirements

Name_________________________ Date_________________________ Class________

For this project, you will be working in a group of three.

Each group member is responsible for completing one of the interdisciplinary connections below.

Each group member must complete a different task.

You must research your interdisciplinary connection on the internet or at the library. This information SHOULD NOT come from the “top of your head”, it requires research!

Each group member must prepare a visual to share with the class, as well as a list of websites or books where they found the information.

You should not go out and buy any special materials for this project. I will provide poster paper, and any other materials you use should be common, everyday items.

The due date for this assignment is this coming Monday. You will need to research at home and bring in what you found to work on during class. You are responsible for managing your time and resources effectively.

INTERDISCIPLINARY CONNECTIONS

- TECHNOLOGY: Investigate the technologies that have enabled humankind to extract fossil fuels from the Earth. Make a poster or powerpoint of what you found.
- SOCIAL STUDIES: Probe the historical circumstances surrounding the extraction and usage of fossil fuels in ancient times. Make a poster or powerpoint of what you found.
- LANGUAGE ARTS: Write a speech to persuade others of the finiteness of fossil fuels, or be creative and make a commercial, song, poem, or other writing piece of your choice. Prepare it to share with the class.
- MATHEMATICS: Obtain data on fossil fuel production and consumption and plot it on graphs. Make your graphs large enough so they can be seen when posted.
- HEALTH: Investigate the health hazards of using fossil fuels, particularly the diseases and accidents that have affected coal miners. Write a few diary entries of people who were afflicted or make a poster teaching about it.
- HOME AND CAREER SKILLS: List the uses of fossil fuels in the home and in various careers.
- ARTS: Design a poster or brochure to inform others that the supply of fossil fuels is finite.
- FOREIGN LANGUAGE/CULTURES: Find out which nations of the world have the greatest reserves of fossil fuels and which nations have the least reserves of fossil fuels. Prepare a visual to teach how these reserves affect the lifestyles of inhabitants of those nations.

Note: you can put a creative twist on any of the above ideas.
Appendix G

Student-guided inquiry

KWL Chart

Name: ____________________________
Date: ____________________________

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<th>What We Want To Find Out</th>
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References


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