

WHAT IS THE IMPACT OF INTERACTIVE SCIENCE NOTEBOOKS ON STUDENT
SUCCESS IN SCIENCE?

by

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Susan Munson Johnson

July 2013

DEDICATION

This paper is dedicated to my husband who cooked, cleaned (sometimes) and rubbed my back while I tried to overcome the challenges of completing this study. This is also dedicated to all those involved in making the MSSE program at Montana State University happen. Special thanks go out to Walt Woolbaugh who was incredibly patient with me this past year. This has been a tremendous learning experience.

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ABSTRACT

The purpose of this study was to implement Interactive Science Notebooks with the intention of improving student success in science. The notebook intervention format involved metacognitive strategies including student-designed reflect and connect pages. Data collection instruments included a Likert-style student confidence survey taken pre- and post-study, summative test score comparisons, teacher reflective journal notes, classroom assessment techniques, rubrics for student notebook entries, student and focus group interviews. The use of the interactive science notebook encourages independent thinking, metacognition, and student confidence in science. The results indicate that when students utilize the Interactive Science Notebook they are more confident in their academic skills, they are more organized, and they perform better on summative assessments. As a result of using the notebooks students demonstrate a stronger capacity to retrieve and apply the information in a variety of settings including real-life applications. When students are using the notebooks the teacher feels satisfied that her students are participating in an authentic and effective learning experience.

INTRODUCTION AND BACKGROUND

Project Background

Teaching and Classroom Environment

I started teaching as a high school science teacher in 1981. Since then I took several years off to raise my family and then, several more because of illness. I returned to teaching in 2004 when I was asked to step in as a long term substitute. I have been teaching science in Connecticut Region 15 schools ever since. In 2006, I joined the faculty of Memorial Middle School in Middlebury, Connecticut as a grade seven life science teacher. This has been my position since that time.

In the seven years that I have been on staff, we have switched from a large team approach to a small team approach and back to a large team approach. As a large team we meet daily to share and discuss student concerns, but we do not all share the same students. We work within a six day cycle. Two days of that cycle I meet with the other life science teacher to coordinate our instruction, one day of that cycle is dedicated to examining guidance and academic intervention plans, and one day per cycle is dedicated to whole school issues.

Every day of our six day cycle we have a study hall period for all students. This provides the structure for the music and art program to offer whole school rehearsals and activities. It is also a time that students can use to complete make up tests, meet with teachers for extra help, or make up missed lab activities.

I meet with each of my five classes every day of the cycle. My smallest class has 18 students, my largest class has 25. Each class is configured heterogeneously.

I try to incorporate authentic science activities into my curriculum. From November to April we raise trout in my classroom. I incorporate outdoor field experiences and, when time or facilities do not allow, I utilize on-line simulation activities. Because each class period meets for only 42 minutes it is often a challenge to complete and process these activities. In other words, I

am continually searching for ways to ensure that my students are able to connect the instructional activity to the unit focus questions.

School Demographics

Region 15 school district incorporates two neighboring towns, Middlebury and Southbury Connecticut. Memorial Middle School is located in Middlebury so most of my students are from Middlebury. Middlebury prides itself as being a small town with state of the art educational activities in a beautiful southern New England setting. The two towns are considered to be made up of primarily middle class to upper middle class residents. According to our school guidance secretary, of the 509 students at MMS there are 20 students who are eligible for the free lunch program and eight students receive a reduced-price lunch. Our district tends to produce students who perform well on state assessments and a high percentage of students go on to pursue college degrees straight out of high school.

Rationale for the Study

Picture a student who is high achiever in your typical middle school. This student scores very high on summative assessments, she completes homework consistently, she is obedient and well-mannered, her parent demands academic excellence. But this student lacks creativity and enthusiasm for true learning. She is not curious. To put it simply, she prefers the worksheet that emphasizes rote learning. She just wants to be told what to write on the line so she can be correct in their response. When asked to derive deeper meaning or application; when asked to design or create something, she looks at you blankly.

Picture a different type of student. This student refuses to become engaged in school work. She sees no value in her academics; she has not been academically successful and does not see why it is important. She has a difficult home life. She rarely does homework, she is well-behaved but unengaged. She stars blankly during class discussion. She continually asks for help to complete the worksheet described above.

Another student has extracurricular activities that take precedence over academics. After all, his parents are certain that his future lies in his athletic prowess. He is academically capable but he rarely completes a homework assignment. He looks for opportunities to distract his classmates and derail the teacher's plan for the day. He fills out the worksheet with answers that do not reflect understanding of the material covered. Later in the day you find his paper on the floor in the hallway.

As described above, many of my students are not independent thinkers. They have limited curiosity or low motivation to achieve academically. They tend to be rote learners. Additionally, our demographic is changing and I am seeing more and more students who have little to no support at home. The general skill set and background knowledge many of my students have is lower than I have ever observed, and student motivation for real learning seems low. As a result, I need a tool that I can use to help them become more aware of their own intellectual capabilities. We all have these types of students. Our task as educators is to find methods to meet each student where she is and bring her to her place of academic strength and confidence. In order to tackle this problem, I have adopted the Interactive Science Notebook.

The Interactive Science Notebook (ISN) has a specific "left-side," "right-side" organization that promotes conceptual understanding as students reflect upon the meaning of the material to be learned. "An interactive notebook is a tool students use to make connections prior to new learning, to revise their thinking, and to deepen their understanding" (Marcarelli, 2010, p. 2). Marcarelli explains it this way, the "interactive notebook provides a space where students may take what is inside their brains, lay it out, make meaning, apply it, and share it with their peers, parents, and teachers" (p. 2). Prior to my study, I believed that, through the use of the Interactive Science Notebook, my students would become more competent independent thinkers. They would perform better on summative assessments, approach scientific challenges with

greater confidence, communicate more fluently, and I would have greater confidence that they are learning science.

When students are using the ISN, they will record information from a lab activity, teacher notes, research notes, or even textbook notes. This is recorded on the right-side page of the notebook. Sometimes this is done as a homework assignment. They are then given time to discuss the key points and to try to examine how the key points fit with one another and how the material is related to the unit focus question. They shift around sticky note papers to develop organizers; they create foldable organizers; they analyze data collected; they create graphs to help them see relationships between data; they ask questions; they argue over the meaning of the data or information. This work is student directed and designed. The methods they use are their own. They will discover through peer and teacher feedback whether or not their methods make sense. They want their methods to make sense because they own them! This is the classroom I envisioned when I was designing my study. My focus questions were developed based upon what I found in the research on this topic and upon the outcome I desired for my students.

Focus Questions

My research questions for this study include the following:

Primary AR question:

What is the effect of interactive science notebooks on student learning and application of science content?

Sub-questions:

1. What is the effect of using the ISN on students' abilities to monitor, organize and take control of their own learning?
2. In what ways does use of the ISN provide insights into student thinking that can be used for formative assessment?
3. What is the effect of the ISN on teacher satisfaction with student learning?

To establish the most efficient way to tackle these question using the ISN, I examined the research already done on the use an effectiveness of science notebooks. I also studied various writing methods used to promote learning in science. Additionally, I investigated brain-based learning methods and looked into what some of the experts say about our role as educators.

CONCEPTUAL FRAMEWORK

I started using the ISN to foster independence and confidence in learning. My intuition told me that the ISN would be an excellent too, but I needed to see if my initial thoughts about the use of notebooks were supported in the research. I also realized that I could gather teaching strategies from others who had already been using this teaching tool. In this section I will explain the philosophy behind the use of the ISN, how the ISN functions as an exceptional learning tool, and I will describe the role the notebook plays in science literacy. I will also describe some of the methods that others have used to research the effectiveness of the Interactive Science Notebook.

Science notebooks have been around for a long time. Personally I remember my chemistry notebook. This was a graph paper notebook in which I recorded prescribed information about the laboratory exercises we completed. These were not thinking tools. Rather, these were places to record the information that our teacher wrote on the blackboard. We then were expected to memorize the information and repeat it back on a test or quiz.

The ISN is not your traditional science notebook. Interactive Science Notebooks provide an opportunity for students to take ownership over their learning. “While acquiring and integrating new knowledge and skills, students come to view the notebook as a personal, organized, and documented record of their understanding” (Crippen, 2009, p.53). Writing is an important way that children learn in science. Young (2003) cites Azimioara, Bletterman, and

Romero n.d., saying it is “when students explain what they have seen and why they think this occurs in writing, they are forced to clarify their thoughts and organize these ideas in a way that others can understand” (Young, 2003, p.44). The interactive notebooks are valuable learning tools because they demand students to participate fully in their learning process. According to Gilbert and Kotelman (2005, p.29), notebooks help students construct their own “conceptual understandings.” With continued use over time, students become more detailed in their observations and they tend to interact more completely with the material.

Scientific literacy is a concept that is gaining strength and momentum. According to Butler and Nesbit (2008) students can truly get a sense of what they think and know when they write in science notebooks. They can check themselves to see if their understanding is complete. This “metacognitive awareness produced by writing can serve as a catalyst for further learning” (p.1). Scientific journals can serve many different purposes. One purpose is to make sense of their investigations. When students are involved in constructing this knowledge they move from “knowledge-telling” to “knowledge-transforming.” In other words, they take ownership of this new, deeper understanding and they can apply it to different settings.

The Memorial Middle School mission statement reads that, “The mission of Memorial Middle School, a community that embraces the uniqueness of each student, is to educate our students to be responsible, productive citizens and life-long learners through engaging learning experiences that are challenging, while nurturing social and emotional development, and creating strong partnerships within the entire community”(Memorial Middle School, 2011). The Region 15 online curriculum document states that, “We strive to prepare our students to be thoughtful, active citizens who can function productively in a multi-cultural, rapidly changing, interdependent world”(Pomperaug Regional School District 15, 2012). How does an educator set out to play a part in accomplishing this? What does this look like in the science classroom?

Prior to my study, I felt the Interactive Science Notebook could contribute to accomplishing the school and district goals, but I needed to see if this was supported in educational literature. Potentially the ISN is a thinking tool. When used effectively, it is a tool into which students can record, reflect upon and revise their thinking.

In an article he wrote for his college newspaper, Martin Luther King Jr. said this about education's role in promoting thinking, "the function of education, therefore, is to teach one to think intensively and to think critically" (King, 1947, p.1). In chapter 12 of John Dewey's book, "Democracy and Education" he describes the importance of developing thinking as a method of intelligent learning (Dewey, 1916).

The sole direct path to enduring improvement in the methods of instruction and learning consists in centering upon the conditions which exact, promote, and test thinking.

Thinking is the method of intelligent learning, of learning that employs and rewards mind. We speak, legitimately enough, about the method of thinking, but the important thing to bear in mind about method is that thinking is method, the method of intelligent experience in the course which it takes. (Chapter 12: Thinking in Education, para. 1).

He recognized that often people view thinking as separate from experience but in that he strongly disagreed. His contention was that when a person is first learning about something he/she must be allowed to test it, play with it, and experience it. He states that successful education occurs when the educator gives "the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking, or the intentional noting of connections; learning naturally results" (Chapter Twelve: Thinking in Education, para. 4). The methodology of the ISN requires that the student will be able to actively engage with the material to be learned, think about its usefulness, and organize the information in a way that has meaning. The methodology encourages the student scientist to transfer the developing knowledge to other settings – making it a working knowledge. In doing so the use of the notebook requires that the student be a

creative collaborator. Small group, partner, and whole class discussions are integral to the usage of the notebooks.

Willona M. Sloan quotes Jonathan Cohen, cofounder and president of the National School Climate Center as saying,

I think that my view, and most people's view, is that the purpose of education is to support children in developing the skills, the knowledge, and the dispositions that will allow them to be responsible, contributing members of their community— This includes “respecting others, working collaboratively, acting in a way that is fair and just, and being an active participant in the life of the community. (Sloan, 2012, para.7).

John Dewey took it a few steps further. He believed that a person’s education needs to provide a complementary mix of experiences that build upon one another. That the experiences need to be varied, they must involve others, and they must be interactive. Every experience is valuable. But time must be taken to think about this new learning. Time must be taken to consider how the new learning changes perspective and understanding. As new experiences are had, connections are made to old experiences and new questions and areas of inquiry are developed (Dewey, n.d.). I think that Dewey would have appreciated the interactive notebook because of its use as a thinking tool.

The notebook is an interactive tool and it is a thinking tool. As technology improves so does our knowledge of how the brain works. I am intrigued by brain research and the applications in an educational setting. I know that this is an emerging area for discussion as neuroscience moves from the theoretical and clinical setting into the classroom. The more I learn about the brain, the more intrigued I am with the potential of the interactive notebook to promote brain development. The body of research in the area of educational neuroscience is growing and there are areas of disagreement. However, there is strong agreement that true learning is advanced when the thinker can reflect upon her thinking and when she can make her

thinking visible (Committee on Developments in the Science of Learning, 2000; Crawford, 2007; Sousa, 2010; Caine and Caine, 1990; Perkins, 2008; Willis, 2007; Wolfe, 2001). This concept, of making thinking visible has been developed extensively by Dr. Ron Ritchhart and his associates who state that through speaking, writing, and drawing, their ideas students deepen their cognition. “For adolescents to become better thinkers, they must be immersed in settings where thinking drives the understanding of knowledge” (Crawford, 2007, p. 109). This type of setting involves providing time for students to reflect upon the material and shape their questions, time for them to formulate and test questions; time for them to collaborate; time for them to discuss, argue, defend and articulate their thinking, time to write about what they know (Lorin W. Anderson, 2001; Crawford, 2007; Ritchhart & Perkins, 2008; Wolfe, 2001).

The adolescent brain is a dynamic organ. Synapses develop and thicken with each new experience (Bransford, 2000; Crawford, 2007; Willis, 2007). Judy Willis (2007) describes the plasticity of the brain and the pruning that occurs. She explains that, despite the misconceptions that say otherwise, brain growth does not stop with birth. We are not doomed to a lifetime of brain cell death during our lifespan. She points out that, while we are born with most of the neurons that we need for life “there is lifelong growth of the supporting and connecting cells that enrich the communication between neurons. These “dendrites” sprout from the neuron’s arms (axons) or cell body” (2007, p. 310). The dendrites will grow in size and number as we develop skills and gather information and experience. These “new dendrites grow as branches from frequently activated neurons” (2007, p. 310).

I enjoyed reading this as I often refer to my students growing “branches in their brains” as I encourage them to ponder, sort, and conceptualize new information. One teacher tells her students that she wants to hear her “synapses sizzling,” as they think, reflect, organize and make sense of the material (Crawford, 2007). Willis cites Giedd et al., (1999) as she describes how the brain’s plasticity allows it to “reshape and reorganize the networks of dendrite-neuron

connections in response to increased or decreased use of these pathways” (2007, p. 310). She points out that when a student revisits material that is to be learned in the classroom, when he rearranges the information and organizes it in new and different ways, more dendritic pathways of access are created in the brain and more connections are made. The more these pathways are used the stronger they become. When they are not used they are “pruned.” With use they grow and branch and connect. With disuse they atrophy and fall away. These branches that are formed while students are making connections in a variety of ways indicate that the material is truly learned not simply stored as short term memory. Crawford says that, “the brain is a pattern seeker that continually attempts to cluster and organize incoming information into previously formed synaptic structures” (p.19). Willis describes teachers as “Memory Enhancers--Not Just Information Dispensers”(2007, p. 312).

At the start of each school year my students seem to prefer rote memory tasks. They have been brought up this way. Rote learning requires very little true thought, just repetition. This does not cause the growth of more “branches.” Unfortunately, material that we “memorize” is most often soon forgotten. These factoids are valuable in a trivia contest but they have no true value when it comes to conceptualizing the material. The goal of brain-based learning is to depend less on rote memorization of material and more on the development of connections and pathways in the brain that lead to efficient retrieval and application of information. This is true learning and the outcome I strive for.

A person’s capacity for learning increases as he or she engages in the process of learning. Whenever a student participates in his/her learning either verbally or in writing, a certain number of neurons are activated. The more these actions are repeated and complemented the more these neurons respond. Responding dendrites sprout more branches making more and stronger connections as new information moves into long term storage (Bransford, 2000; Crawford, 2007; Willis, 2007). The more often these connections are made, the more efficient

the brain becomes in retrieving and utilizing the information.

When students are interested in what they are learning they move this information from their temporary working memory into stored memory (Crawford, 2007; Caine, 1990, Ritchhart & Perkins, 2008; Wolfe, 2001). More connections and stronger circuits are made when the instructor appropriately administers brain-based instructional methods. Instructional methods that have students personalize the information to be learned activates areas of the brain that help form memories (Willis, 2007). Also, when a student can involve the senses while making connections, he or she will create more brain pathways to the material (Crawford, 2007; Willis, 2007; Wolfe, 2001). Visualizing concepts and then recording them using pictures, discussing concepts with a partner and recording anecdotes from the conversation, and forming concept maps or diagrams to describe the material are all activities that enhance the learning process by causing the dendritic pathways to be increased and strengthened (Bransford, 2000; Crawford, 2007; Sousa, 2010; Willis, 2007; Wolfe, 2001).

Research shows that brain function increases as students are immersed in an active, personal, and engaging learning environment. Classroom use of the interactive notebook models this type of brain-based learning. As a result of using the notebooks students should demonstrate a stronger capacity to actually retrieve and apply the information in a variety of settings. The use of the interactive science notebook encourages independent thinking, metacognition, and student confidence in science. Through the use of the ISN, the student works within his/her own learning style and at a level that is differentiated to his/her own ability level. Through the notebooks students have a way of organizing the information that is delivered to them via teacher notes, content outlines, and other factual information. They can create meaning from information by developing organizers, generating drawings, and designing memory tools. Each time a student constructs a method to communicate the information she is learning, she is stimulating neural development. Knowledge is built through this process. I believe that when a

student can take charge of her own learning she will develop a positive attitude toward learning science. When students take charge of their learning, when they can apply new knowledge to alternate situations, when they express a positive connection to the science they are learning, then teacher satisfaction with her students' learning increases.

METHODOLOGY

Study Participants

This study involved 64 7th grade students in my 1st, 2nd, and 5th period life science classes. There are 23 students in my period 1 class, 24 students in my period 2 class, and 18 students in my period 5 class. All but one of these students returned a signed Subject Consent Form (Appendix A). These classes provide a good representation of the type of student that we have enrolled in Region 15. These classes also provide a good representation of the type of student that I tend to have year after year in my classes. Within each class, I have many students who are engaged and enthusiastic participants, and I have fewer students that tend to be passive, non-verbal learners. Of these students, 31 are female and 33 are male; five receive support through the special education department or through an in-house tutoring program.

Region 15 provides a comprehensive science curriculum from grades kindergarten through 12. Students in seventh grade have previously had coursework that exposed them to science inquiry and the scientific method, life science, physical science, and earth science.

Region 15 schools are classified in the Connecticut District Reference Group (DRG) B. The DRG is a "classification system in which districts that have public school students with similar socioeconomic status (SES) and need are grouped together (Prowda, District Reference Groups, para.1). To form the DRG classification groups, income, education, occupation, family structure, poverty levels, home language, and district enrollment are all considered. The District Reference Group B of which this district is a part, is second only to DRG A, and so it represents a population that holds a high socioeconomic status in Connecticut.

Project Design

This action research project involved the incorporation of an Interactive Science Notebook (ISN) as a learning tool for students. The research methodology for this project received an exemption by Montana State University's Institutional Review Board (Appendix B) and compliance for working with human subjects was maintained.

The year started with a pre-treatment unit where the ISN was introduced and ISN methods were practiced. This was to ensure that all students were comfortable with the treatment tool before the actual study began. The project involved two non-treatment and two treatment units of study. Prior to the first non-treatment unit, 64 students from my periods 1, 2, and 5 classes completed the Student Confidence Survey. These same students completed the survey at the end of the final treatment unit. The units are described in the table below.

Table 1

Action Research Unit Titles and Connecticut Science Standards Alignment

Unit Title	Treatment/ Non-treatment	Unit Focus Question	CT Standard	Grade level concepts
What is Life?	Non-treatment	In what ways are all living things the same?	7.2.a. All organisms are composed of one or more cells; each cell carries on life-sustaining functions. 6.2.a. Populations in ecosystems are affected by biotic factors, such as other populations, and abiotic factors, such as soil and water supply.	7.2.a.1 6.2.a.7
Unit Title	Treatment/ Non-treatment	Unit Focus Question	CT Standard	Grade level concepts
Cells	Treatment	Why are cells considered to be the basic units of structure and function in all living things.	7.2.a. All organisms are composed of one or more cells; each cell carries on life-sustaining functions. 7.2.b. Multicellular organisms need specialized structures and systems to perform basic life functions.	7.2.a.1, 2, 4 7.2.b.2, 3, 4
Cell Transport	Non-treatment	How does a cell maintain homeostasis in a changeable environment.	7.2.a. All organisms are composed of one or more cells; each cell carries on life-sustaining functions.	7.2.a.4
Energy in Ecosystems	Treatment	How do biotic and abiotic factors work together to move energy through an ecosystem?	6.2.a. Populations in ecosystems are affected by biotic factors, such as other populations, and abiotic factors, such as soil and water supply. 6.2.b. Populations in ecosystems can be categorized as producers, consumers	6.2.a.1, 2, 5, 7 6.2.b.1 - 10

			and decomposers of organic matter.	
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The treatment phases involve using the Interactive Science Notebook as a tool for students to record the content matter, organize their understanding of the content matter, reflect upon that understanding, revise their understanding, and then apply the new knowledge. All work is recorded in the ISN. The key factor that separates the ISN from other science journals is that it is designed to encourage active discourse student to student, instructor to student, and even within the individual student as he struggles to develop meaning within the content. While this type of discourse happens often in the classroom that does not employ the ISN, it is more emphasized when the notebooks are in use.

At the start of each unit, treatment and non-treatment, I use an *Engage* activity that is intended to create curiosity and spark discussion that ultimately leads to identification of the core ideas and generalizations, or key questions of the up-coming unit. Often this is a video or YouTube clip. Occasionally I will read an excerpt from the news. The unit progression that follows includes the elements of the 5E Learning Cycle: *Explore, Explain and Clarify, Expand, Evaluate*. The treatment and non-treatment activity progression is indicated in Table 2.

Table 2
Summary of Treatment and Non-Treatment Instructional Overview

Non-treatment	Treatment
Engage activity	Engage activity
Pre-test/knowledge probe	Pre-test/knowledge probe
Assign unit focus questions	Engage: Design and create unit cover page
Explore: Involve readings of interest, videos, lab activities.	Engage: Unit focus question development
Explain: Note-taking – from teacher and/or text	Explore: Involve readings of interest, videos, lab activities.
Mid unit Evaluation: Administer CAT; types will vary	Reflect and Connect (<i>R&C</i>)
Expand: Online interactive learning activities; projects/models; lab activities and inquiry investigations	Explain: Note-taking – from teacher and/or text
Explain: Whole group discussion	Student small group discussion of material followed by <i>R&C</i> .
Evaluate: Summative test with case study scenario	Mid unit Evaluation: Administer CAT; types will vary
	Expand: Online interactive learning activities; projects/models; lab activities and inquiry investigations
	Student small group discussion of material followed by <i>R&C</i> activities.
	Explain: Whole group discussion and synthesis followed by connections made on <i>Light Bulb</i> or <i>Aha</i> Page.
	Evaluate: Notebook Rubric
	Evaluate: Summative test with case study scenario

As we work through treatment and non-treatment units, students will complete traditional style assignments such as labs, note-taking, readings, and worksheets. The difference between the treatment and non-treatment units is that, during the treatment period, students will use the ISN and this involves the incorporation of the metacognitive tools that are inherent in the design of the ISN. In all units, key information is recorded or stored in a notebook. For the non-treatment units these are three-ring binders. For the treatment units these are the Interactive Science Notebooks.

While using the ISN my students know that the right hand pages involve input of factual information. These are described by Marcarelli (2007) as the “input” pages. On these pages students will take class and textbook notes and they will record factual information from the text or resources such as worksheets and the internet. Lab activity problem statements, background information, hypotheses, procedures and data are all recorded on the right-side pages. The left side pages are where they process through the information that has been recorded on the “input” page, these are described as the “output” pages. On these pages they develop organizers to help them make sense of the information. They pose questions and propose answers – the left side pages are where the pondering and grappling for meaning takes place (Appendix C). In other words, the left side pages are where the learning occurs!

To use the ISN, I first require my students to develop a unit cover page (Appendix D). This is done early in the unit before any content material has been explored by the students. The unit cover page is always a right-side page. In order to design the unit cover page during the treatment unit I provide my students with the sections in the textbook that we will be using during the unit. Students are expected to pre-read these sections, anticipate the primary focus points and then represent these focus points on the cover page. The assignment requires them to use their own personal creativity in the design. The entire illustration must be hand done and I encourage them to use color. At this point in the unit they do not know the unit focus question(s), and so I also encourage them to come up with a title for the unit.

When the cover pages have been completed, I use a pair/share technique followed by a group share activity so that students can view each other’s work. I ask the students to choose cover pages that seem to be especially descriptive of the material. Using a document camera, I share these and together we develop the unit focus question(s). I admit I direct this so they end up with the question that I want to use! One unit focus question that we used during this study was, “How do biotic and abiotic factors work together to move energy through and ecosystem.”

During this unit, I included information from five sections of the text including content material on energy roles in the ecosystem, food webs, food chains and the energy pyramid, photosynthesis, and respiration.

The unit focus question is recorded on the two pages that follow the cover page. This is called the *Aha Connections* (Marcarelli, 2007) or *Light Bulb* page. This page always involves two right- and left-side pages that face each other. A light bulb is drawn in the center (to illustrate the “Aha” moment), and the unit focus question is written inside. Throughout the unit, students record key points that help answer this question. For example, during the unit described above, one of my students described a lab activity where she investigated the effect of temperature on the rate of photosynthesis. She explained that temperature is an abiotic factor that can limit or improve the rate of energy production in an ecosystem. This is an ongoing pursuit. It is expected that students will be able to record information on this page during each phase of the unit. It is on the *Aha* page that students are striving to connect and apply the content to a bigger picture – this is where transfer of knowledge occurs. I have included a tutorial that I developed to help teach my students how to use this page as Appendix E. An example of a student created *Aha* page is included as Appendix F.

Many of the notebook pages are record keeping pages. Since I chose to use the model developed by Kellie Marcarelli, these are usually right side pages. The record keeping pages are content input pages. They include pages for recording lab and other science activities, research notes, as well as note-taking pages that involve class and textbook notes. But to just write this information down is not enough. Students do not really learn the material just by writing it down. To truly learn, a student must grapple with the material and explore how it fits into the bigger picture. To do this students are asked to develop their *Reflect and Connect* pages.

Reflect and Connect (R&C) pages are left-side pages. They are found opposite the content input pages and they are where a student’s thinking is made visible. During small group

discussions, class discussions and individual student reflection time, students are working to make greater sense of the material. A visitor will see them discussing and arguing over the meaning of the content material. The students will be highlighting key points, grappling with connections using sticky notes and other graphic organizer tools, they will be drawing pictures, diagrams and webs to try to show meaning (Appendix G). During one *R&C* class session several of my students grappled with the relationship that exists between photosynthesis and respiration. They were able to create a circular diagram that involved drawings of a mitochondrion and a chloroplast. Using arrows they included inputs and outputs of carbon dioxide, water, oxygen, and energy.

I view the *R&C* pages and the *Aha Connections* pages as essential to the philosophy of the ISN. It is on these pages where metacognition, or student thinking, is made visible. This is where each student grapples with the meaning of the material and organizes it in a way that makes sense. Throughout the notebook we keep the same left side/right side format (Marcarelli, 2010). I chose to use the ISN plan developed by Kellie Marcarelli because her book was easy to follow and use. Marcarelli describes the left side or “output” pages as the place where students ponder the material, ask questions and develop meaning. The right side pages are designated for content material. Primarily, this is where the student records his notes from the textbook or teacher lectures. This is also where laboratory hypotheses, procedures, and observations (Marcarelli) are recorded.

During non-treatment phases the curriculum is delivered using similar teaching methods but the ISN is not used. There is no *Aha* page and there is no *R&C*.

Data Collection Techniques

An independent learner is one who is able to monitor, organize and take control of his/her learning. This type of student will be able to apply science knowledge learned in the classroom to real world applications. And, when I see this type of student working in my classroom I will

feel confident – satisfied, that learning is happening. Throughout the learning cycle, to insure validity and reliability during treatment and non-treatment periods, I collected both qualitative and quantitative data. Quantitative data sources include the Student Confidence Survey (Appendix H), pre-test and post-test scores, and notebook evaluations using a rubric (Appendix I). Qualitative data was collected through the teacher field journal (Appendix J) and the student in class interviews. To help insure validity and reliability these data were compared to each other through triangulation, and I asked a colleague to review my interpretations in order to avoid the trap of personal bias or wishful thinking. Table 3 provides a summary of my data collection instruments.

Table 3
Data Collection Matrix

Research question	Teacher field journal	Rubric for case study problem on post-test	Pre and posttest data	Likert style student confidence survey	CAT's	Student interviews and/or focus groups	Student generated notebook entries graded with rubric
What is the effect of interactive science notebooks on student learning and application of science content?	☒	☒	☒		☒		☒
What is the effect of using the ISN on helping students to monitor, organize and take control of their own learning?	☒			☒	☒	☒	☒
Research question	Teacher field journal	Rubric for case study problem on post-test	Pre and posttest data	Likert style student confidence survey	CAT's	Student interviews and/or focus groups	Student generated notebook entries graded with rubric
In what ways does use of the ISN provide insights into student thinking that can be used for formative assessment?	☒			☒	☒	☒	☒
What is the effect of the ISN on teacher satisfaction with student learning?	☒	☒	☒	☒	☒	☒	☒

What is the effect of interactive science notebooks (ISN) on student learning and application of science content? The answer to this question was indicated by collecting and analyzing pre- and post-test data. Each post-test included a case-study problem. I expected my students would show a greater ability to respond to these questions during the treatment units. My field journal and focus group responses were also intended to shed light on this question as I

observed how students handled these types of problems during the summative assessment and then, how they discussed their problem solving process during the focus group interviews. The field journal notes and focus group responses also provided key data for answering my first sub-question: What is the effect of using the ISN on students' abilities to monitor, organize and take control of their own learning? Additionally, the Confidence Surveys, allowed me to track my student's beliefs about their abilities to be successful students. As I observed my students during all aspects of the study I was able to observe their work habits. I was able to record their ability to locate information, process information, and utilize information in the forming of responses to Classroom Assessment Technique (CAT) assignments, case-study questions, and inquiry tasks.

During class meetings and during spot notebook checks after school, I collected information that helped answer my second sub-question: In what ways does use of the ISN provide insights into student thinking that can be used for formative assessment? I monitored my student's ideas, thought development, and misunderstandings by regularly (as much as possible) assessing their ISN work. These check points also served as formative assessment tools. My students' perceptions of their abilities in science were surveyed pre-study and post-study using the GoogleDocs survey tool. The data collection tools described above provided a rich compilation of qualitative and quantitative evidence for analysis.

DATA AND ANALYSIS

Data from the treatment, non-treatment, and pre-treatment periods were collected and compared in order to determine the impact of Interactive Science notebooks on student learning. By examining data from the Student Confidence Surveys, summative assessment scores, formative assessment scores, the teacher reflective journal and student interviews I hoped to gain a clear picture as to the effectiveness of the ISN as a learning tool.

The pre-study and post-study Likert style Student Confidence Survey was used to gain a sense of student perceptions of their abilities and to help me determine if using the ISN helps my students to monitor, organize and take control of their own learning. A copy of this survey is included as Appendix H. I anticipated that these perceptions would change over the course of the treatment periods. I expected that, through the use to the ISN, students would begin to change as learners and their overall confidence would grow as they began to take advantage of the diversified manner in which learning takes place when interactive notebooks are employed. Through the survey I was able to identify some very distinctive ways in which my students' perceptions of their own abilities improved (Figure 1).

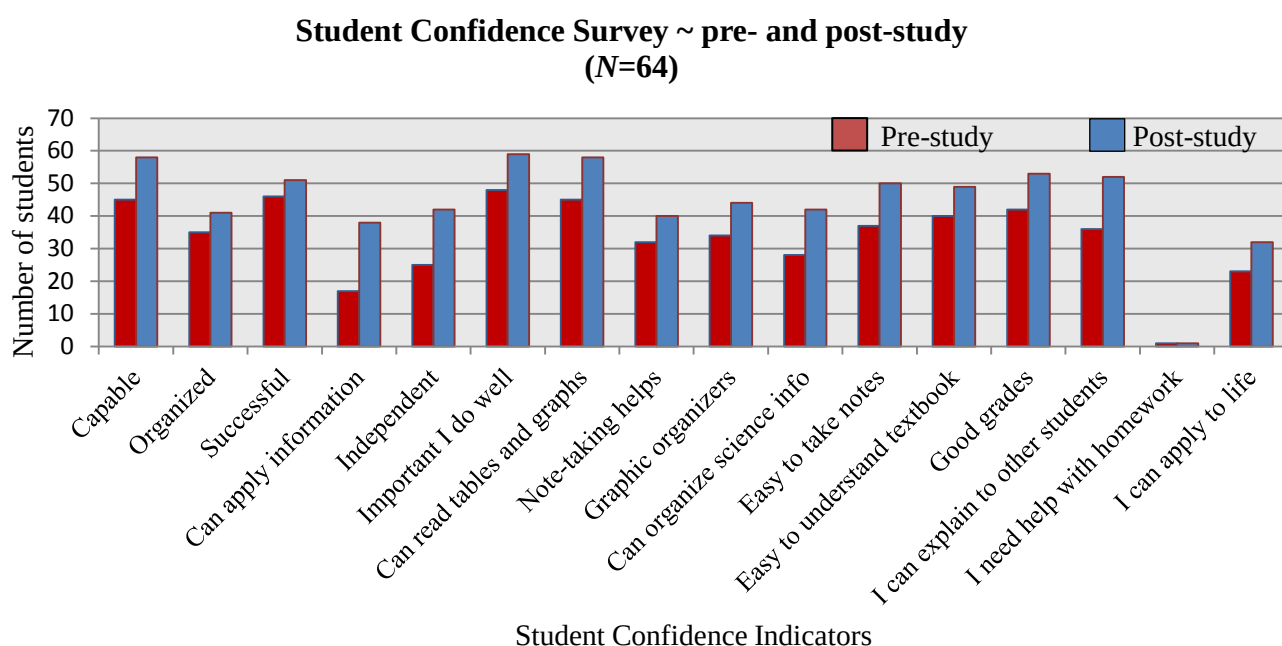


Figure 1. Comparison of student confidence survey results, pre-study vs. post-study, (N=64).

A comparison of the results of the pre- and post-study Student Confidence Survey shows that in most areas surveyed, the students in the study group (students from periods 1, 2, 5) felt more confident and more capable at the end of the study than they did at the start. I found the results of several questions to show a significant improvement in student perception about their abilities in science. For example, post-study, the number of students who indicated they felt

capable increased by 29% (N=64) over the pre-study survey, and 17% more thought they were organized. When asked, “If you agree (that you are organized) what do you do to stay organized? If you disagree, provide an example of your disorganization,” the student written responses were revealing. In the pre-study survey, when describing his favorite organizational method one student wrote, “I dot [sic] have a favorite method... -- I just know where everything is, even when it is messy.” He gave himself a high rating “Agree”(4) for his ability to organize. Another student who also scored herself an “Agree” (4) rating for organization wrote, “i work very hard to keep things in the proper place. on weekends I organize my notebooks.[sic]” But post-study I received different types of answers. The male student mentioned above wrote, “I rely(really) like how everything we do in science is all organized in the ISN I can find evrything I need.[sic]” The female student mentioned above responded, “i like to use the reflect and connect in my interactive notebook. I personally think the isn is a great idea. it teaches us to be organized and reinforces certain skills.[sic]”

Early in the study I asked my focus group questions about the use of the ISN and their ability to organize. At that point I was very concerned about their abilities to use the notebook. One student told me, “The notebook is difficult... I’m used to being told what to do.” Another student said, “It’s annoying. I don’t need it. It’s just extra baggage. What is an Aha page anyway!” He made his comment in a very cutting way. I felt awful!

But then about midway through the study I also asked them again about their ability to organize. One student said, “Overall I used to be a massive mess in all subjects, but I am definitely the most organized I have ever been in science.” Another commented, “the notebook has definitely helped me to stay organized. I feel I would be lost without it.” The boy who thought the ISN was just extra baggage continues to dislike it to this day.

For the most part, however, I felt that they did indeed come to appreciate and value the ISN. At the start of the final treatment unit one student in the focus group commented, “When

reading all the information in the book I feel overwhelmed sometimes because I feel like I'm supposed to understand it all when really I could barely comprehend the first couple of pages after I read the whole section once. When we work with the ISN though, I think I have an easier time handling the facts, because I am able to organize all my thoughts and other information from the book." During the cell transport unit, which was not a treatment unit, seven out of 18 (39%) students in my period 5 class asked, "Can we use our ISN?"

Another significant improvement that was noted by comparing the Pre-study Student Confidence Survey and the Post-Study Student Confidence Survey was that, when students were asked if they could apply the science they learn in class to life, there was a 124% increase in student confidence in this area! This information was validated through the observations that I recorded in my Teacher Field Journal. For example, before our treatment periods were over I had to take a break from the curriculum to close out our trout unit and to take my students outdoors for our annual trout release. We had just completed the Energy in Ecosystems unit which was a treatment unit. I asked my students to visually assess the environment into which we were releasing the trout. Each member of the small group to which I was speaking was able to participate in a discussion of both the abiotic and biotic factors they felt would impact our trout. They also predicted the outcome of each survey (biological, chemical, physical) we would complete that day. Here is an excerpt from my final journal entry:

What an amazing day! This was the most successful trout release I have had so far. I really loved how my students understood the value of assessing the stream before we actually released the trout. Even though we completed the Energy unit over a week ago they applied most of what we had discussed. They discussed the abiotic features with ease. And describing possible food chains seemed to come easily. In all the years we have done a trout release I have never seen anything like it! (April 12)

Also significant to the study, in the post-treatment survey 68% more (than in the pre-study) of my students said they felt as if they were strong independent learners. Additionally, 30% more students felt confident reading tables and graphs, 29% were more confident using graphic organizers, 50% more were confident in their abilities to organize their science materials and 44% more students felt as if they can explain the science they are learning to their classmates.

My teacher reflective journal notes revealed the same level of progress. This is shown clearly by comparing a journal entry written early during my research with an entry written later in the study. First, an excerpt from my journal early in the study:

UGH! I am feeling very frustrated. My students are not using the *R&C* time well. They are not connecting that the info they record is what they need to learn. Their *R&C* page is filled with a rewriting of their notes – almost sentence for sentence. They want to be told what to do! Their *Aha* pages are blank. I feel so defeated. This is supposed to be encouraging independence! (November 16)

Early during the study I was very frustrated with my students' lack of ability to work independently, to take charge. But later I recorded some very positive comments:

This is a beautiful thing! What a wonderful day. During the *R&C* time my students had great discussions and then they set about to create some fantastic – creative and effective summaries of the material. Some students drew pictures, others created webs or diagrams. Several of my students then transferred the key points – REALLY THE KEY POINTS – to the *Aha* page. It's beginning to feel worthwhile. (March 21)

There were three questions on the Confidence Survey where the results did not show improvement. When asked if they thought they were organized at school, on both surveys, pre- and post-study there was no change, thirty-nine percent of the students believed that they are organized. Also only one percent of students, pre- and post-study, indicated that they frequently

need help with homework. I had expected the pre-study responses to be high and, in comparison, I had expected the post-study responses to show more independence and capability in this area. Apparently my homework is just not that challenging!

Finally, when students were asked about how they felt about their success as students, pre-study 52% agreed that they are successful students. Post-study this number dropped. Only 49% of students felt successful at the conclusion of this study. This does not represent a large difference but, still, I was concerned. So, while this was not one of my original questions for the focus group, I felt I needed to ask them about their lowered sense of success. Overall, the response was simply that the science taught in grade seven is so much more difficult than the science taught in grade six. However, a look at the summative test results shows them to be fairly successful when it comes to test performance, and test scores are an important measure of success.

As I was preparing to conduct this study, I hoped that use of the ISN would increase student learning and application of science content. If the ISN had this effect, I anticipated that student summative test scores would have a positive correlation to the scores they received when I assessed their work in the notebooks. Effective use of the ISN was measured using the Interactive Science Notebook Rubric that is included as Appendix I. If the ISN is an effective tool, I expected that students who used the ISN well would have better overall test scores. Likewise, students who did not use the ISN well would tend to have lower test scores. In using a scatter plot I hoped to see a strong positive correlation between the two variables. I would also be able to more clearly identify outliers in this relationship.

The strength of a relationship between two variables is indicated by the number of points that fall on or near the line of regression. Figure 2 illustrates the relationship between ISN score and summative test scores at the end of the first treatment period, the Cell unit. Figure 3

illustrates the relationship between ISN score and summative test scores at the end of the second treatment period, the Energy in Ecosystems unit.

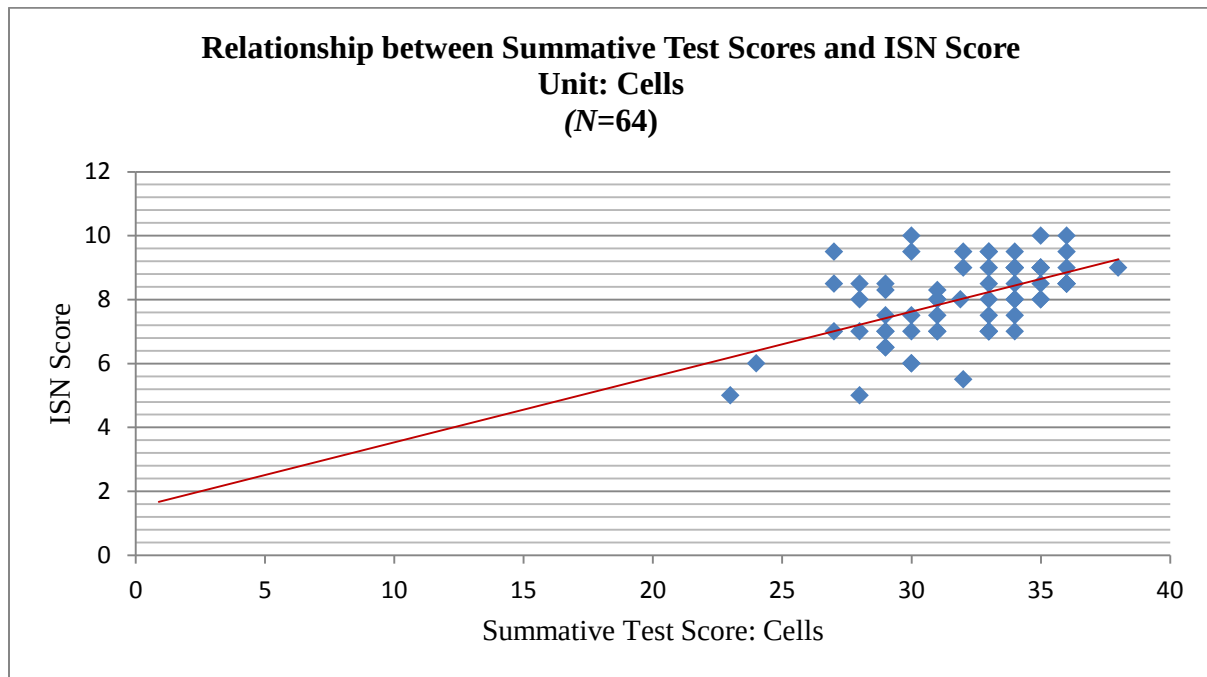


Figure 2. Relationship between the summative test scores and the ISN score during the unit on cellular structure and function, (N=64).

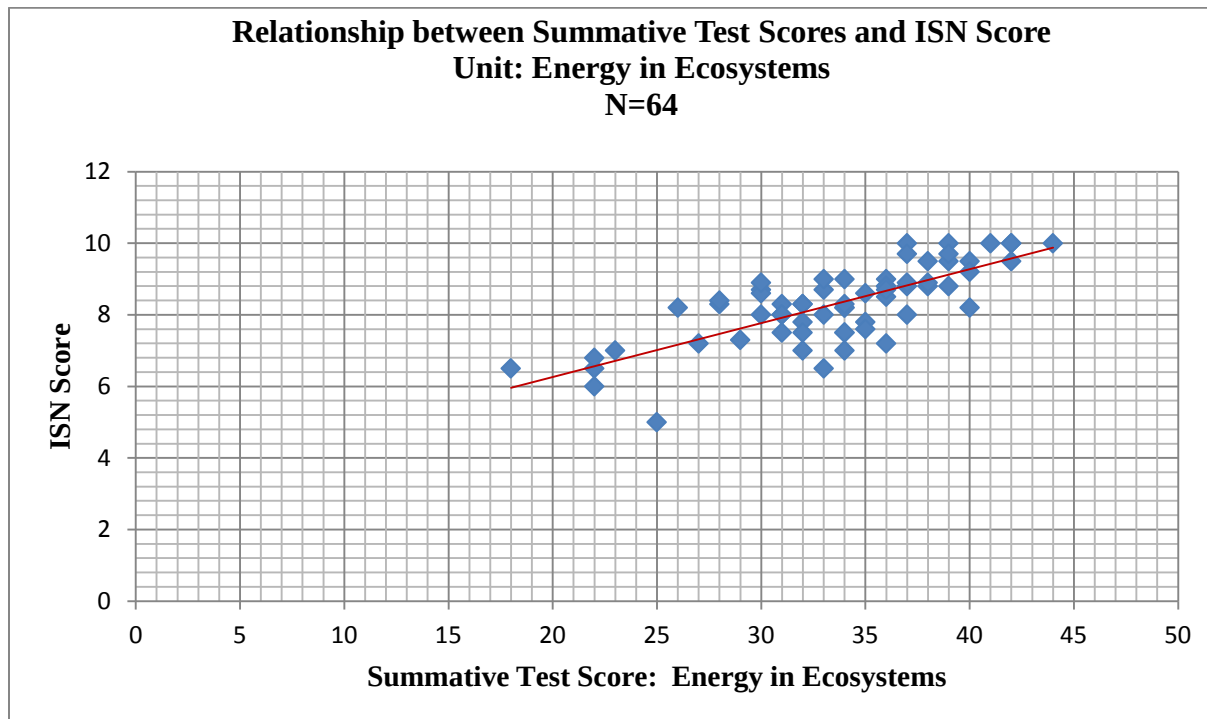


Figure 3. Relationship between the summative test scores and the ISN score during the unit on energy in ecosystems, (N=64).

In both graphs a positive correlation between ISN scores and summative test scores is indicated. But both graphs have a fair amount of data that falls significantly outside the line of regression. So much so, that I feel I cannot call these points outliers. However, during the final treatment period, the Energy in Ecosystems unit, fewer data points are found distant from the line of regression. This shows a tighter correlation between student ISN scores and success on the summative assessment. As they grew more comfortable with the learning methods used with the ISN, my students have used the ISN more effectively. Their use of the ISN has become more closely tied in with their success on assessments.

But a comparison between ISN scores and summative assessment scores does not provide enough information to form a conclusion about the effect of the ISN on student success in science. It is likely by the very nature of the learner that students who prepare well enough to score well on summative tests will also diligently complete their ISN assignments and vice versa. To examine this question more closely, I also compared student performance on the application (case study) questions that are included in all summative assessments. This comparison is included as Figure 4.

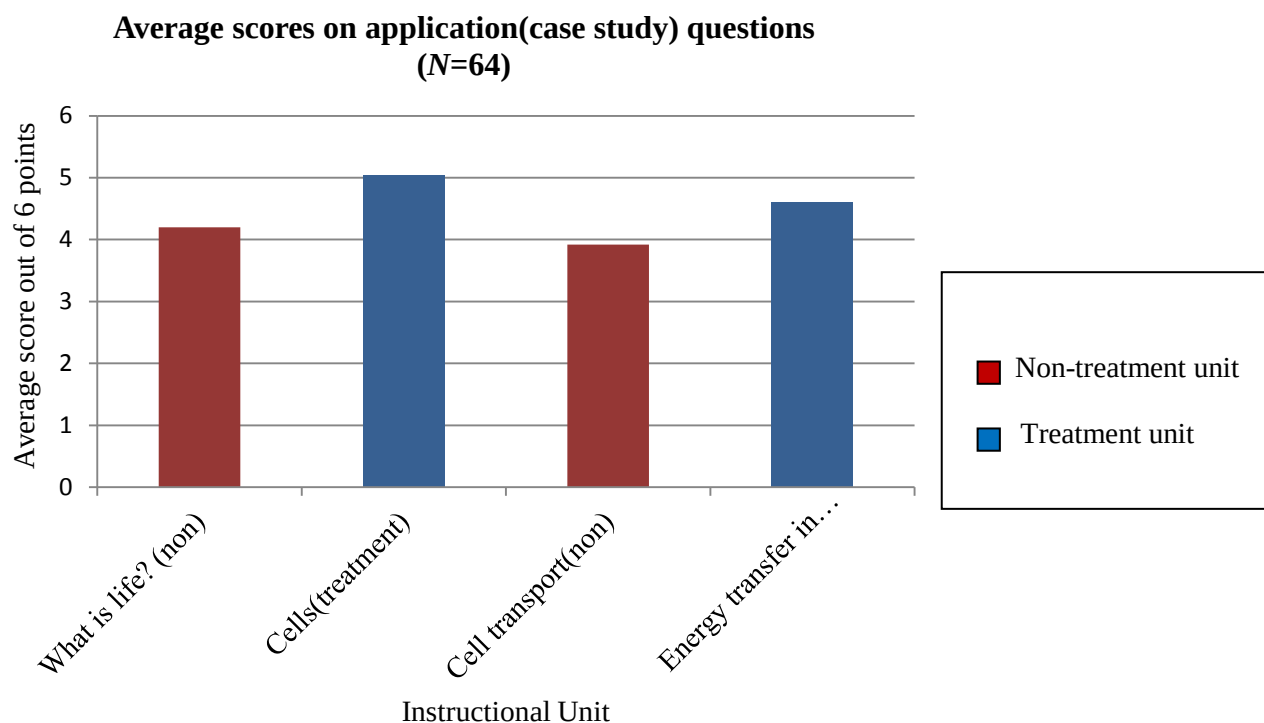


Figure 4. Comparison of points earned on “application” test questions, (N=64).

The graph clearly indicates that during both treatment units students scored higher in their responses to the case study questions than they did during the two non-treatment units. I was also impressed by student responses to the treatment unit application questions. Their answers, more often than not, were fully illustrated and explained. Use of the unit key terms was phenomenal. I did not see this level of understanding during the non-treatment units. If I could repeat this study I would have had a more demanding rubric for the treatment application question responses!

Finally, in order to examine the effect of the ISN on student success in science, I also compared summative pre- and post-test scores during the treatment units with summative pre- and post-test scores during the non-treatment units (Figure 5).

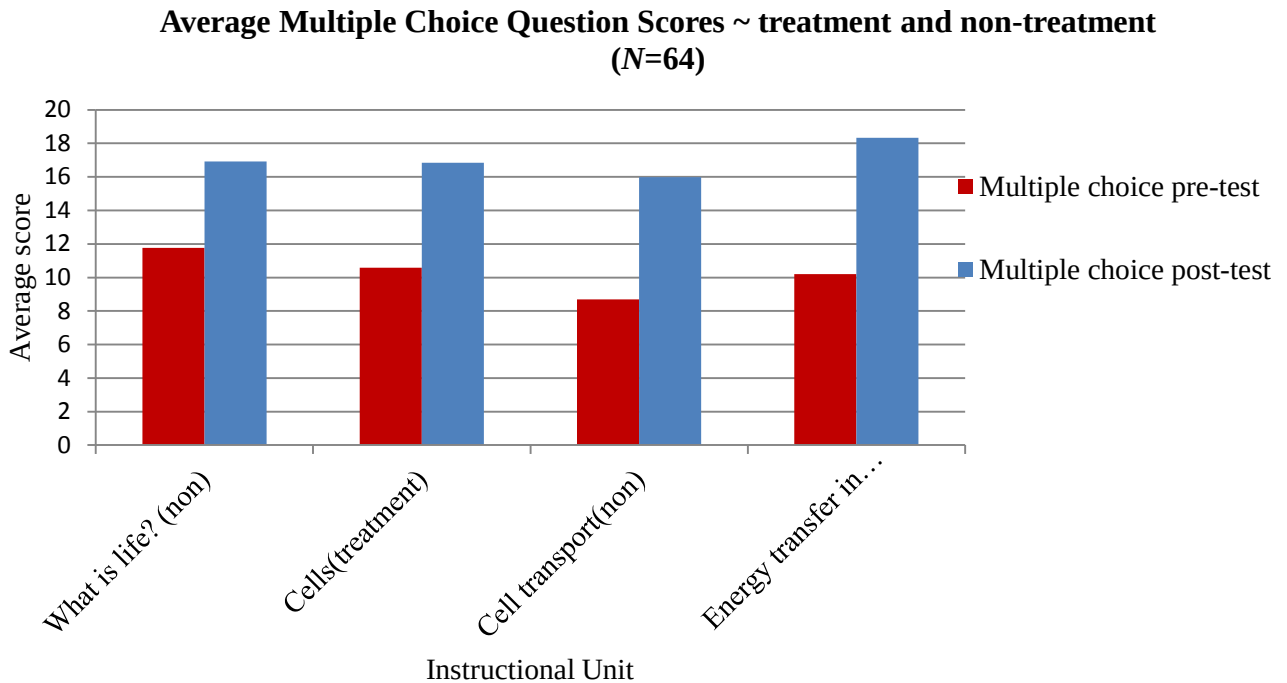


Figure 5. Comparison of pre- and post-test data, (N=64).

To draw a comparison between these values I calculated the percentage improvement between the pre-test scores and the post-test scores. There was a 44% improvement during the “What is Life?” unit, a 59% improvement during the Cells unit, an 84% improvement during the Cell Transport unit, and a 80% improvement during the Energy in Ecosystems unit. These results do not shed light on the effectiveness of the ISN and that is disappointing. If I could repeat this study I would try to design a stronger testing method. For the pre- and post-test data, I used only the multiple choice section of the summative tests. Students tend to be able to recognize key terms and thus select correct responses even when they do not know the material well. After examining these data I have begun to question my use of multiple choice tests. In the future I plan to develop stronger assessment methods.

To examine these data from another perspective I compared the test score averages (Figure 6).

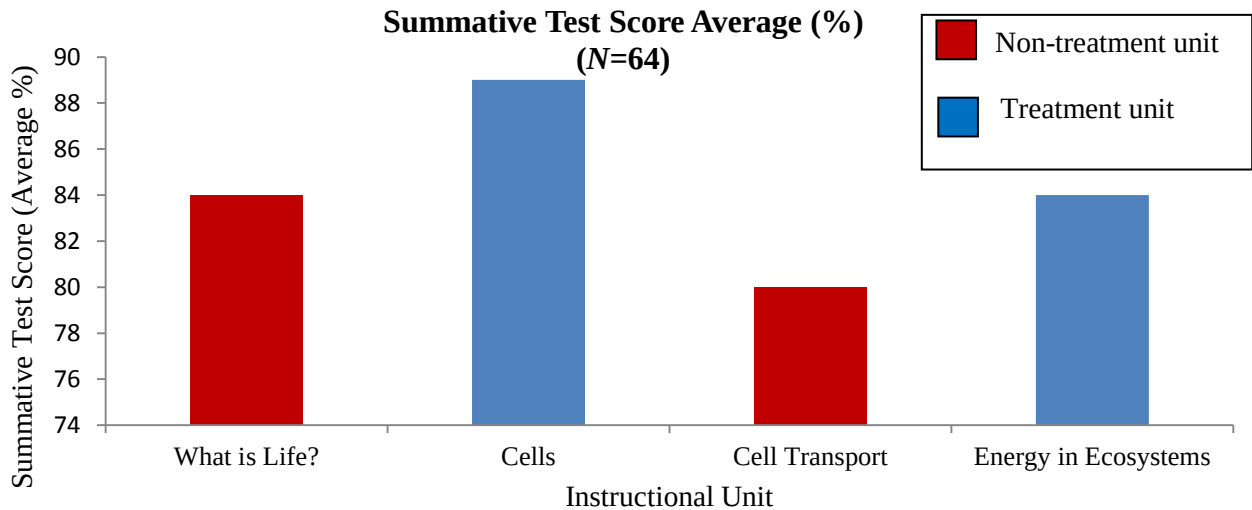


Figure 6. Comparison of summative test score averages, ($N=64$).

These data are very revealing. Clearly my students performed much better on the summative tests during the treatment units as opposed to the non-treatment units. During the What is Life? and Cell Transport units the average score for the 64 students involved in this study was 84% and 80% respectively. During the treatment units, Cells and Energy in Ecosystems, the average summative test scores were 89% and 84%. This data revealed that my students were more successful during the treatment units. To see how my period 5 students felt about their performance on these tests, after each test I asked them how they felt they did. I did this by asking them to give a “thumbs up,” a “thumbs sideways,” or a “thumbs down.” After the What is Life? unit approximately 65% of my student felt they did well – thumbs up. I expected that because this unit covered material they were previously familiar with due to the fifth grade curriculum. During the Cells unit, a significant number of students, about 85% showed thumbs up. Students felt fairly confident after the Cell Transport unit, about 70% thumbs up, and after the Energy in Ecosystems unit, about 75% of my period 5 students felt confident. This informal survey was recorded by quickly looking over the group while I was asking. I made a quick estimate and moved on with my lesson plan.

I also wanted to examine the use of the ISN as a tool to see into my students' thinking. I wanted to see if the ISN could be used as a type of formative assessment tool. At the beginning of this study, I felt that interactive science notebooks could be used as tools for formative assessment. I also thought that the ISN would be a good tool for differentiation as students can choose the techniques they use in their record keeping and student discussions help students vocalize the material they are grappling with.

In order to conduct a formative assessment during class time I targeted a class period where students needed to grapple with the content. During this time I moved about the class and asked individuals and groups of students questions that were content focused. I tallied the number of correct responses and recorded these scores on my Teacher Reflective Journal data sheet. This was done during treatment and non-treatment periods. Table 4 summarizes the results from my period 2 class during each of the study units.

Table 4

Formative Assessment Responses During Treatment and Non-Treatment Periods (N=64)

Unit	Question/topic	Number of correct responses	Number of questions asked	Percentage correct
What is Life? (Non-treatment)	Classification: given characteristics can you classify the Domain or kingdom to which the organism belongs?	4	7	56%
What is Life? (Non-treatment)	Question regarding homeostasis.	3	5	60%
Cells (Treatment)	In what types of cells would you expect to find a lot of: mitochondria; lysosomes	5	6	83%
Cells (Treatment)	What is the value of having specialized cells.	4	6	67%
Cell transport (Non-treatment)	What would happen to a cell that is placed in a solution that has a higher concentration of water outside the cell? Explain why this happens.	3	5	60%
Cell transport (Non-treatment)	What happens to your cheek cells when you drink a lot of soda? Why?	2	7	29%
Unit	Question/topic	Number of correct responses	Number of questions asked	Percentage correct
Energy in Ecosystems (Treatment)	How does sunlight provide food for a zebra?	5	7	71%
Energy in Ecosystems (Treatment)	Do autotrophs conduct cellular respiration? Explain.	4	7	57%

The field note data reveal that during these specific class periods my students were more apt to correctly answer the questions during the treatment periods than they were during the non-treatment periods. More importantly, they were more often able to provide information that had been recorded during classwork as their evidence. For example, when asked during the cell unit, “in what types of cells would you be more apt to find a lot of mitochondria?” one student thought for a moment, turned to the ISN page where he had described the mitochondria,

identified the function, and then he blurted out, “OUR MUSCLES! They need a lot of energy to do work so they would need more mitochondria!” His enthusiasm was so uncharacteristic of his personality I had to laugh! But during the cellular transport unit when asked, “What happens to your cheek cells when you drink a lot of soda?” My students overwhelmingly were unable to construct an answer. When asked to locate something that would help them to figure it out they seemed helpless and they asked if they could look it up on the computer.

Even though my action research project data collection is completed, I continue to use the ISN as a teaching tool. Because assessment of the notebooks takes a lot of time, I debated whether or not to continue its use. However, a recent observation recorded in my field journal during a class period when my students were working on an online lab activity represents my thoughts on the subject and serves as a good final comment:

My students have begun to work well independently. They seek each other out to discuss the topic. They look through the ISN to help them find meaning as they work through this lab. They are very comfortable recording information in the ISN and they are recording information on the *R&C* and *Aha* pages without prompting. The students are focused as they question, collaborate, discuss and problem solve. I wish I was being observed today – they make me look good! (March, 15).

The data sources described above were triangulated to inform me as to the effectiveness of the Interactive Science Notebook in improving student success in science.

INTERPRETATION AND CONCLUSION

The results of this action research project indicate that the use of the Interactive Science Notebook can contribute to student success and confidence in science. My primary research question asked if the use of interactive science notebooks can increase student understanding and application of science content. The first sub-question asked about the effect of the ISN on a student’s ability to monitor, organize and take control of their own learning. The second sub-

question asked how the ISN could be used as a type of formative assessment, and the third sub-question asked if I felt satisfied that my students were learning when they were using the ISN.

To determine the effect of interactive science notebooks on student learning and application of science content, I analyzed pre- and post-test data. The results of this comparison were, overall, inconclusive (Figure 5). There was a 44% improvement during the What is Life? unit, a 59% improvement during the Cells unit, an 84% improvement during the Cell Transport unit, and a 80% improvement during the Energy in Ecosystems unit. When I was pondering these results I felt as if the multiple choice questions might not have been the best tool to determine the extent that learning was taking place. I felt that the multiple choice questions did a better job testing my students' ability to take a multiple choice test than they did at testing content knowledge. However, when I examined the case-study results, where I compared the scores on case study questions during each unit (Figure 4) I found that during the two treatment units my students scored higher on the case-study questions than they did during the two non-treatment units. Moreover, I was impressed by the level of the responses. Students effectively used more key terms and provided more details in their responses during the treatment periods. Many students' responses far exceeded my expectations! Finally, when I compared the summative test scores during the non-treatment units with the summative test scores during the treatment units I found that my students in the study had better results during the treatment units.

This data was further validated by the formative assessment responses (Table 4) that I collected during the units. Responses during the non-treatment period were correct only 50% of the time while the responses during the treatment periods were correct 69% of the time. Additionally, I was once again impressed by the ways in which my students were able to cite examples or provide evidence for their responses. My field journal entries on the days that I conducted in-class interviews described the confidence and enthusiasm with which my students

responded to verbal questioning during the treatment units. These were moments to be treasured!

To see if the ISN had an effect on my students' abilities to monitor, organize and take control of their own learning, I first conducted a Student Confidence Survey. The purpose of the Confidence Survey was to see if student perceptions of their abilities in science changed during the course of the study. The data revealed that student confidence increased across the duration of the study (Figure 1). Student responses to the Student Confidence Survey revealed information about their perceived abilities to monitor, organize and take control of their own learning in science. Pre-study, 45 of the 64 students who responded to the survey agreed that they felt capable as students. This improved to 58 students in the post-study survey. That is a 29% improvement! The reflective journal data reinforced my sense that students felt more capable in science post-study than they did pre-study. For example, in one entry I recorded a student's comment about the use of the ISN, "The notebook is difficult... I'm used to being told what to do." He did not feel confident in his abilities. Yet, during a mid-study interview the same student said, "the notebook has definitely helped me to stay organized. I feel I would be lost without it."

Over all student responses showed an increase in their confidence in 15 of 21 questions. Students felt they were more independent, more capable, more organized, and they felt as if their science skills improved. Students also felt more confident in their abilities to create data tables and graphs, develop graphic organizers, and explain the work to other students. These responses complement observations I recorded in my journal. Early in the study I was concerned because they were unable to develop their *R&C* pages without my prompting. During one in class interview I recorded a student as saying, "I can't seem to organize the information. I like it better when you give us a worksheet." But later, as the study came to a close, another said,

When reading all the information in the book I feel overwhelmed sometimes because I feel like I'm supposed to understand it all when really I could barely comprehend the first couple of pages after I read the whole section once. When we work with the ISN though, I think I have an easier time handling the facts, because I am able to organize all my thoughts and other information from the book.

Comments from my journal showed a strong frustration during the first treatment unit but by the last treatment unit I was energized by the conversations I was hearing and the connections they were recording. It took time to develop this community of learners. I expect that in future years this will become more streamlined as my methods become more refined. I also believe that with consistent use of the notebooks during every unit, as opposed to just the treatment units, students will adapt to the use of the notebooks more quickly.

My second sub-question asked if the ISN could provide insights into student thinking that can be used for formative assessment. I found that the ISN can indeed be used as a formative assessment tool. Frequent notebook checks, small group conferences, and in-class student interviews each gave a quick snapshot of how student understanding of the content matter was progressing. Unfortunately, while the notebook checks provided valuable insight into my students' understanding of the material, they were labor intensive, so much that I do not feel that I will continue them. Taking the time to read the notebooks and provide valuable feedback took a disproportionate amount of time during this study. I believe that student interviews and over the shoulder glances during the class period are the extent to which I can use the notebooks as formative assessment tools. This will be an area for additional research.

The third sub-question asked about the effect of the ISN on teacher satisfaction with student learning. I feel very satisfied that student learning was improved through the use of the ISN. While their performance on the multiple choice sections of the summative tests did not reveal a positive or negative correlation, the results from the application or case-study questions

and the summative test score averages did. During the non-treatment units the average student scores on the application questions were 70% and 65%. During the treatment units the average student scores on these questions were 84% and 77%. Not only did they score well on these questions, during the final treatment period they were also able to apply the content material during an outdoor field experience. In interviews conducted during class students readily responded with competence and confidence to questions about the material. The summative test score averages showed a higher level of overall success during the treatment units than during the non-treatment units. Moreover, my students expressed a higher level of confidence the day after taking the treatment unit summative assessments than they did after the non-treatment assessments.

VALUE

The Interactive Science Notebook can be a valuable learning tool. When used on a regular basis, it promotes metacognition, student directed organization of information, and constructive discourse between student scientists. However, there are drawbacks. The ISN is a labor intensive teaching tool. Students need to be provided with ample opportunity several times a week to develop their *R&C* and *Aha* pages. Teacher feedback is essential but it is difficult to schedule time to do this and, with a large number of students, evaluation of the notebooks is time consuming and exhausting. Also, unfortunately, the ISN is not for all students. It is especially challenging to students who have the need for significant academic accommodations. As a result, the teacher needs to be able to take the time to develop tools to assist these students.

Through this experience I have learned a lot and there are several aspects of this project I would do differently if I were to do this again. I did not feel that my pre-test and post-test data collection was very well designed. I have realized a strong weakness in my development of test questions (I use the textbook test bank program). If I could do this again, I would spend more time upfront thoughtfully creating test items. In the end, I also did not like the rubric that I chose

to use to grade the notebooks at the end of each unit. It was repetitive in some of the criteria and it did not include other key components of the notebook. In the future I will develop my own rubric. I also thought it would be a good idea to compare summative test scores with notebook rubric scores. I expected to see a strong correlation. I did see a correlation but it was not tight. I also realized that a student who works hard to do a good job in the ISN will also work hard to do well on a summative assessment. So this was not really a great measurement tool. I wish I had anticipated the challenges that my students had in creating their *R&C* pages at the start of the study. I really needed to have more models and methods designed ahead of time. If I had these in place at the start of the study, this would have gone more smoothly. Finally, I'm not sure that I like the right side – input, left side – output organization of the notebook. Since students normally move from left to right, I think instruction might flow more smoothly if input were recorded on the left side pages and the corresponding output were recorded on the following right side pages.

I have found that I really like the unit cover page assignment. I found that this activity alone does a lot to promote student curiosity and focus during the unit. By asking my students to pre-read and then create the cover page I am encouraging them to start thinking about the content right away. This seems to establish a strong foundation for learning.

Overall, I was happy with the outcome of my treatment units. I felt that the case study data provided valuable information with regard to student learning. The summative test score results also showed my students to have a greater level of success during the treatment periods. I loved watching my students work during the final treatment period. They were focused, creative, animated, and engaged. My students have definitely progressed as competent students. They like their notebooks and want to continue using them. One student remarked, "I really wish other teachers used notebooks like this. I love how I am able to personalize my study notes."

I chose to work with the Interactive Science Notebook for this action research study for many reasons. One important reason is that our district has been considering implementing science notebooks in grades kindergarten through eight. While I feel that the results of this study promote the implementation of notebooks, I think that there is work to be done before they should be required. First, I would like to review other instructional methods that promote brain-based learning. If I am to continue the notebook, a new, revised notebook grading rubric and more authentic summative assessment methods should be developed. There also needs to be a more effective method for using the ISN as a type of formative assessment. Modifications must be developed for special education students, and there must be a more streamlined technique for providing timely feedback to students.

The ISN is a good learning tool but there is more to be done to make it an excellent learning tool. I will use it again next year after incorporating the changes that I have recommended above. The notebook's value lies in the fact that when an ISN is in use there is dynamic discourse in the classroom that promotes metacognition. Students develop conceptual understandings as they discuss, collaborate, evaluate, and describe content material in order to make their thinking visible to themselves and others. By revisiting the content, reorganizing it in meaningful ways, and connecting it to an overriding question or real-life application, neural development is enhanced and knowledge is transformed. This is when true learning takes place. Through this study I have found that the use of the Interactive Science Notebook has a positive impact on student success in science.

REFERENCES CITED

- Anderson D. R., Lorin W. (2001). *A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Addison Wesley Longman, Inc.
- Azimioara, M., C. Bletterman, & P. Romero. (n.d). *Another Approach to the Scientific Notebook*. A collection of Articles and Rubrics. Tustin School District: Tustin, Calif.
- Bransford, John D. et al. (2000). *How People Learn: Brain, Mind, Experience, and School*. Washington: National Academy Press.
- Braxton, E. *The implementation of Interactive Science Notebooks and the effect it has on students writing*. Unpublished professional paper, University of Central Florida.
- Butler, Malcolm B. & Catherine Nesbit (2008): Using Science Notebooks to Improve Writing Skills and Conceptual Understanding, *Science Activities: Classroom Projects and Curriculum Ideas*, 44:4, 137-146.
- Caine, R. N. (1990). Understanding a Brain Based Approach to Learning and Teaching. *Educational Leadership*, 66-70.
- Chesbro, R. (2006, April-May). Using Interactive Notebooks for Inquiry-Based Science. *Science Scope*, 30-34.
- Cho, J. A. (2011). Improving science learning through the use of an interactive science notebook (ISN) pedagogy in a new tonality. *Pedagogy in a New Tonality*, 149-165.
- Crawford, G. B. (2007). *Brain-Based Teaching with Adolescent Learning in Mind*. Thousand Oaks: Corwin Press.
- Crippen, C. W. (2009). Integrating Interactive Notebooks. *The Science Teacher*, 51-55.
- Cumbo, J.. *Will the Use of Interactive Scientific Notebooks Improve Students' Use of Science Content When Making Predictions, Formulating Connections, and Problem Solving in the Science Classroom?* Unpublished professional paper, Caldwell College.
- DeLuca, Joseph John. (2011). *The effect of science notebooks on student achievement*. Unpublished professional paper, Montana State University- Bozeman.
- Dewey, J. (1916). *Democracy and Education: An Introduction to the Philosophy of Education* New York: Macmillan.
- Dewey, J. (1994). *Democracy and Education*. Retrieved October 13, 2012 from, <http://www.gutenberg.org/files/852/852-h/852-h.htm>
- John Dewey. (n.d.). Retrieved October 13, 2012 from, http://en.wikipedia.org/wiki/John_Dewey

- Giedd, J., Blumenthal, J., Jeffries, N., Castellanos, F., Liu, H., Zijdenbos, A., Paus, T., Evans, A., & Rapoport, J. (1999). Brain development during childhood and adolescence: A longitudinal MRI study. *Nature Neuroscience*, 2, 861-863.
- Gilbert, J., & Kotelman, M. (2005, November). Five Good Reasons to Use Science Notebooks. *Science and Children*, 28-32.
- King Jr., Martin Luther (1947). *Dr. Martin Luther King Jr.* Retrieved October 13, 2012 from, <http://www.drmartinlutherkingjr.com/thepurposeofeducation.htm>
- Marcarelli, K. (2010). *Teaching Science With Interactive Notebooks*. Thousand Oaks: Corwin Press.
- Memorial Middle School. (2012). MMS Mission Statement. Retrieved October 13, 2012 from, <http://www.region15.org/subsite/mms/page/mms-overview-6668>
- Perkins, R. R. (2008). Making Thinking Visible. *Educational Leadership*, 57-61.
- Pomperaug Regional School District 15. (2012). Curriculum document. Retrieved October 13, 2012 from, <http://www.region15.org/subsite/dist/page/curriculum-4889>
- Sloan, W. M. (2012, July). ASCD. Retrieved October 13, 2012 from, <http://www.ascd.org/publications/newsletters/education-update/jul12/vol54/num07/What-Is-the-Purpose-of-Education%C2%A2.aspx>
- Sousa, David A., E. (2010). *Mind, Brain, and Education: Neuroscience Implications for the Classroom*. Bloomington: Solution Tree Press.
- Willis, Judy M. (2006). *Research-Based Strategies to Ignite Student Learning*. Alexandria: Association for Supervision and Curriculum Development.
- Willis, J. (2007). Brain-based teaching strategies for improving students' memory, learning, and test-taking success. *Childhood Education*, 83(5), 310+.
- Wolfe, P. (2001). *Brain Matters: Translating Research into Classroom Practice*. Alexandria: Association for Supervision and Curriculum Development.
- Young, J. (2003). Science interactive notebooks in the classroom. *Science scope* (Washington, D.C.), 26(4), 44.
- Zimmerman, B. (1989). A Social Cognitive View of Self-Regulated Academic Learning. *Journal of educational psychology*, 81(3), 329-339.

APPENDICES

APPENDIX A

SUBJECT CONSENT FORM

**SUBJECT CONSENT FORM
FOR
PARTICIPATION IN HUMAN RESEARCH AT
MONTANA STATE UNIVERSITY**

Project title: *What is the Impact of Interactive Science Notebooks on Student Success in Science?*

Dear Parent/Guardian,

I am currently working on a Master's degree in Science Education through Montana State University. As part of my graduation requirement I am studying the impact of Interactive Science Notebooks (ISN) on student success in science. This note is to ask for your permission to include your child, _____, in my research study.

Not all of my students will be involved in this study. However, all of my students will be using the ISN during our course of study. I have already initiated notebook use during our introductory unit on science skills. As the topics become more complex (cells, cell processes, genetics) the notebooks will be used to an even greater extent. I am hoping to include all of my period 1 and period 5 students in this study. These two classes provide a good cross section of Memorial Middle School student abilities. Participation, however, is totally voluntary and a student can choose to opt out at any time. In addition to the normal classwork, students who participate in the study will be asked to complete two confidence surveys and I may ask them to participate in a student focus group during an agreed upon lunch/recess period. I will be grading and providing feedback in all my student notebooks but data from my study group will be included in my final report. I will also use pre and post-test data, results of case-study assignments and journal observations to support my findings. All of these assignments are already integrated into the life science curriculum. They do not represent additional work for your child. Finally, I may ask your child if I could include a photo of his/her notebook in my final report and presentation. During no part of my research will I identify your child or use

his/her name. Participation or non-participation will not affect the student's grade or class standing.

The ISN promotes writing in science. It has been found to foster metacognition, content mastery, and independent learning. Use of the notebook encourages students to think deeply about the topics they are learning and it helps them to see how the science they are learning applies in the world outside their classroom. As Region 15 works to adopt the Common Core State Standards there will be a focus on science literacy. Currently the Region 15 Science Curriculum team, of which I am a member, is looking closely at the incorporation of student notebooks in K-8 science classes as one way to address the science literacy standards. At the end of the year I hope to present my research to the curriculum team.

It is my belief that the ISN can be an effective tool in helping students become strong independent learners as it encourages them to think more deeply about the material they are studying. I look forward to working with the 41 students in my period 1 and my period 5 classes. I hope you will see your child's participation in this study as valuable. Please contact me by email at sjohnson@region15.org or phone (203)758-2496 with any questions or concerns. If you have additional questions about the rights of human subjects you may contact the Chair of the Institutional Review Board at Montana State University, Mark Quinn, (406) 994-4707, mquinn@montana.edu.

Regards,

Susan M. Johnson, Memorial Middle School grade 7 science

AUTHORIZATION: I have read the above and understand the discomforts, inconveniences and risks of this study. I, _____ (*name of parent or guardian*), related to the subject as _____ *relationship*, agree to the participation of _____ (*name of subject*) in this research. I understand that the subject or I may later refuse participation in this research and that the subject, through his/her own action or mine, may withdraw from the research at any time. I have received a copy of this consent form for my own records.

Parent or Guardian Signature: _____

Child's Assent Signature: _____

Investigator: _____

Date: _____

APPENDIX B

MONTANA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD EXEMPTION



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

960 Technology Blvd. Room 127
 c/o Immunology & Infectious Diseases
 Montana State University
 Bozeman, MT 59718
 Telephone: 406-994-6783
 FAX: 406-994-4303
 E-mail: cherylj@montana.edu

Chair: Mark Quinn
 406-994-5721
 mquinn@montana.edu
Administrator:
 Cheryl Johnson
 406-994-6783
 cherylj@montana.edu

MEMORANDUM

TO: Susan Johnson and Walt Woolbaugh
FROM: Mark Quinn, Chair *Mark Quinn ex'*
DATE: December 10, 2012
RE: "What is the Impact of Interactive Science Notebooks (ISN) on Student Success in Science?"
 [SJ121012-EX]

The above research, described in your submission of December 10, 2012, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- X (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- X (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

**SUBJECT CONSENT FORM
FOR
PARTICIPATION IN HUMAN RESEARCH AT
MONTANA STATE UNIVERSITY**

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APPROVED
MCUIRB
12-10-2012
Date approved

It is my belief that the ISN can be an effective tool in helping students become strong independent learners as it encourages them to think more deeply about the material they are studying. I look forward to working with the 41 students in my period one and my period five classes. I hope you will see your child's participation in this study as valuable. Please contact me by email at sjohnson@region15.org or phone (203)758-2496 with any questions or concerns. If you have additional questions about the rights of human subjects you may contact the Chair of the Institutional Review Board at Montana State University, Mark Quinn, (406) 994-4707, mquinn@montana.edu.

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Parent or Guardian Signature: _____

Child's Assent Signature: _____

Investigator: _____

Date: _____

APPROVED
12/17/12
12-10-2012
Quinn approved

APPENDIX C

NOTEBOOK ORGANIZATION AND SET-UP

THE “WHY” OF SCIENCE NOTEBOOKS

To start a science notebook, you will need:

- A notebook (spiral 10.5x8 OR composition 9.75x7.5) with 70-100 pages, without perforations
- Pens and pencils – please use **black** or **blue ink** for written work (excluding graphs, diagrams, sketches, etc.)
- Helpful but not required: colored pencils, metric ruler, eraser, calculator, glue stick/tape
- You will use your notebook every day in class to help you learn new science concepts and make connections between those concepts. Your notebook will also help you organize your thoughts in a neat, creative, organized way. If it's notebook, you'll see it on tests and quizzes!

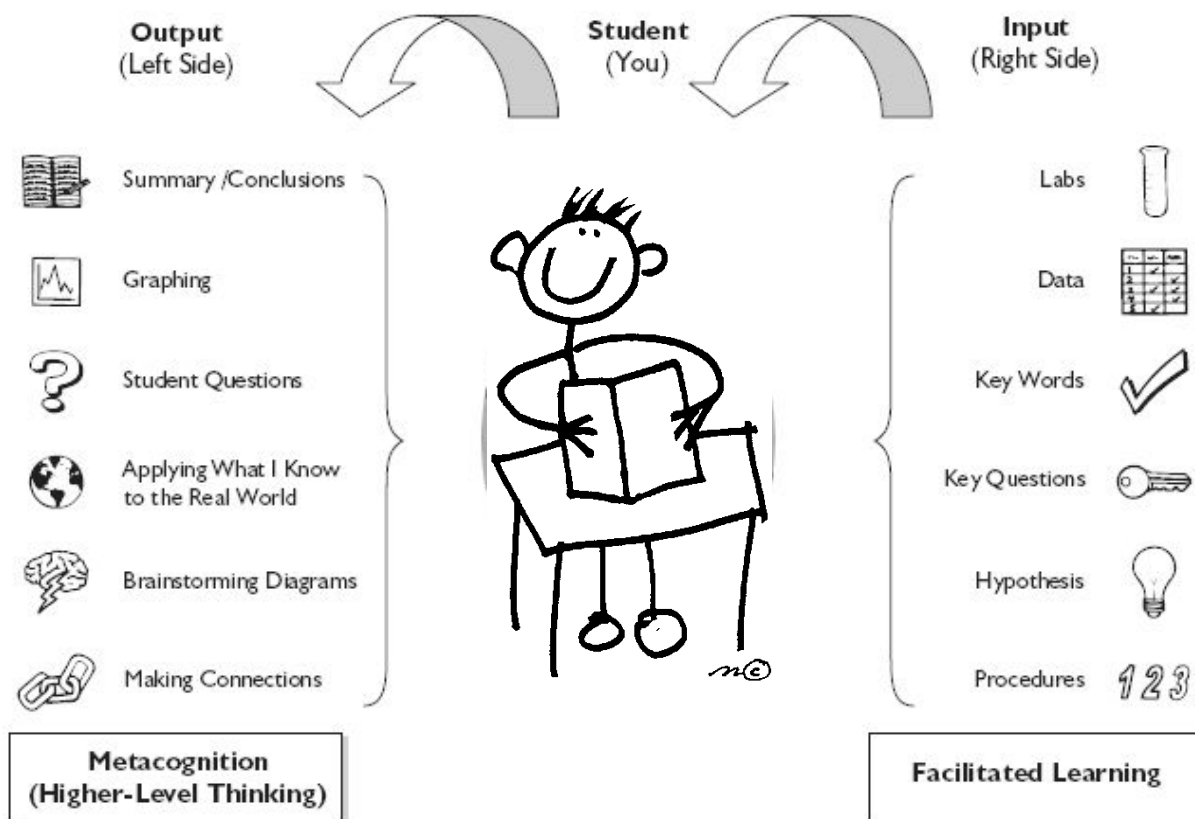
Left Side—Output *Even numbered pages	Right Side—Input *Odd numbered pages
The left side of the notebook is used to show your understanding of the new concepts that you are learning in class. We call this the metacognition, or higher-level thinking, side of your notebook. You will be working with the information from the right, input, side and presenting it in your own way on this left side. We use the left side for . . .	The right side of the notebook is for your facilitated learning. This side is mostly used for the work that you do in class with your teacher and with other classmates. We have a lot of conversations and questions that we try to answer. You will be recording that work on this, right, side of your notebook. We use the right side for . . .
✕ Your questions	✕ Key questions
✕ Brainstorming diagrams	✕ Hypotheses
✕ Making connections	✕ Procedures
✕ Graphing	✕ Labs/Observations
✕ Summary/Conclusions	✕ Data
✕ Applying what you know to the real world/Big Idea	✕ Key words/Notes/Class consensus ideas

Adapted from:

Teaching Science With Interactive Notebooks, by Kellie Marcarelli. Thousand Oaks, CA: Corwin.

Reproduction authorized only for the local school site or nonprofit organization that has purchased this book.

WHAT'S GOING THROUGH MY HEAD?



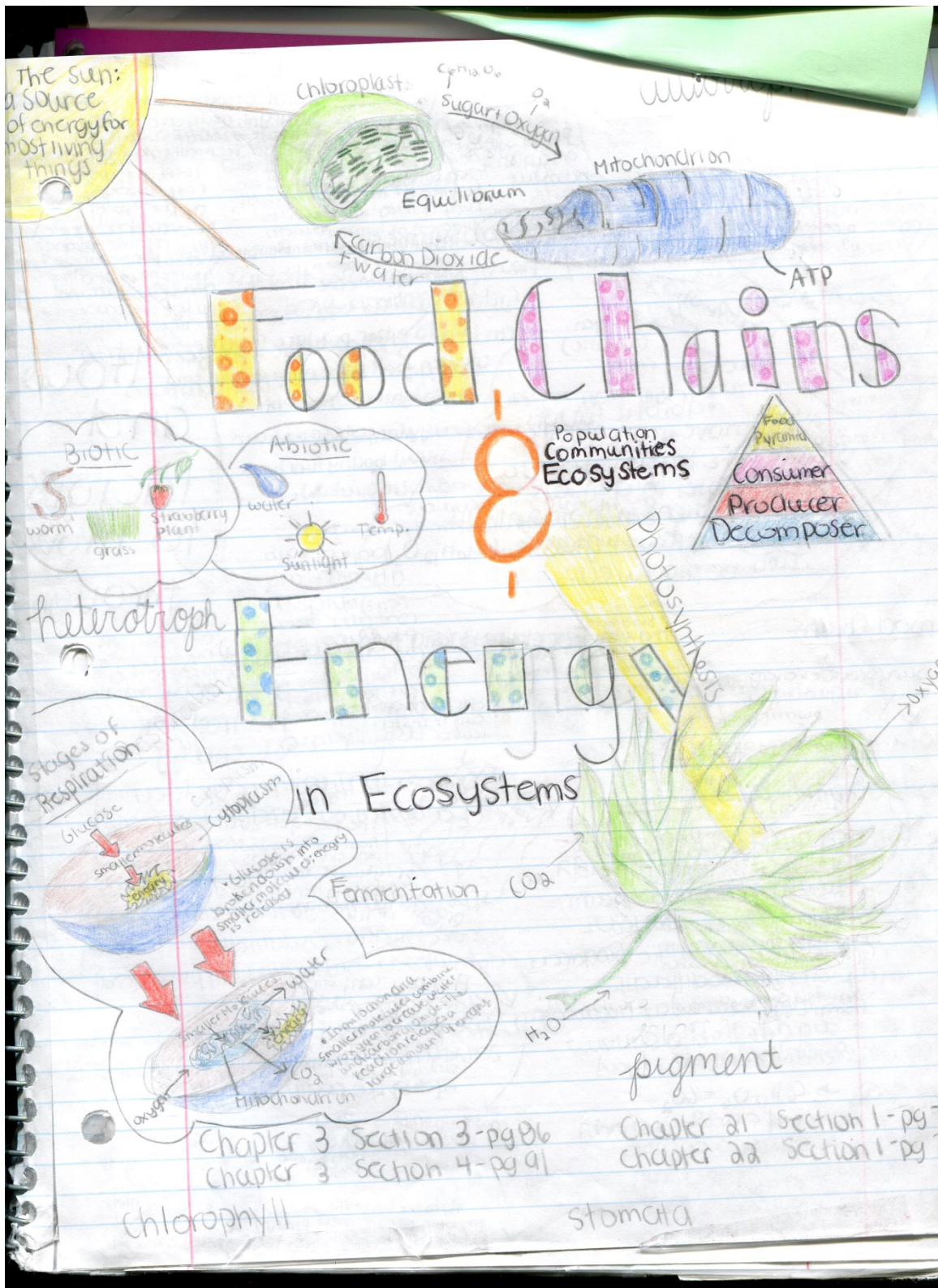
Adapted from:

Teaching Science With Interactive Notebooks, by Kellie Marcarelli. Thousand Oaks, CA: Corwin.

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APPENDIX D

STUDENT CREATED UNIT COVER PAGE



APPENDIX E

AHA CONNECTIONS TUTORIAL

CONSTRUCTING THE AHA CONNECTIONS PAGE FOR OUR CELLS UNIT

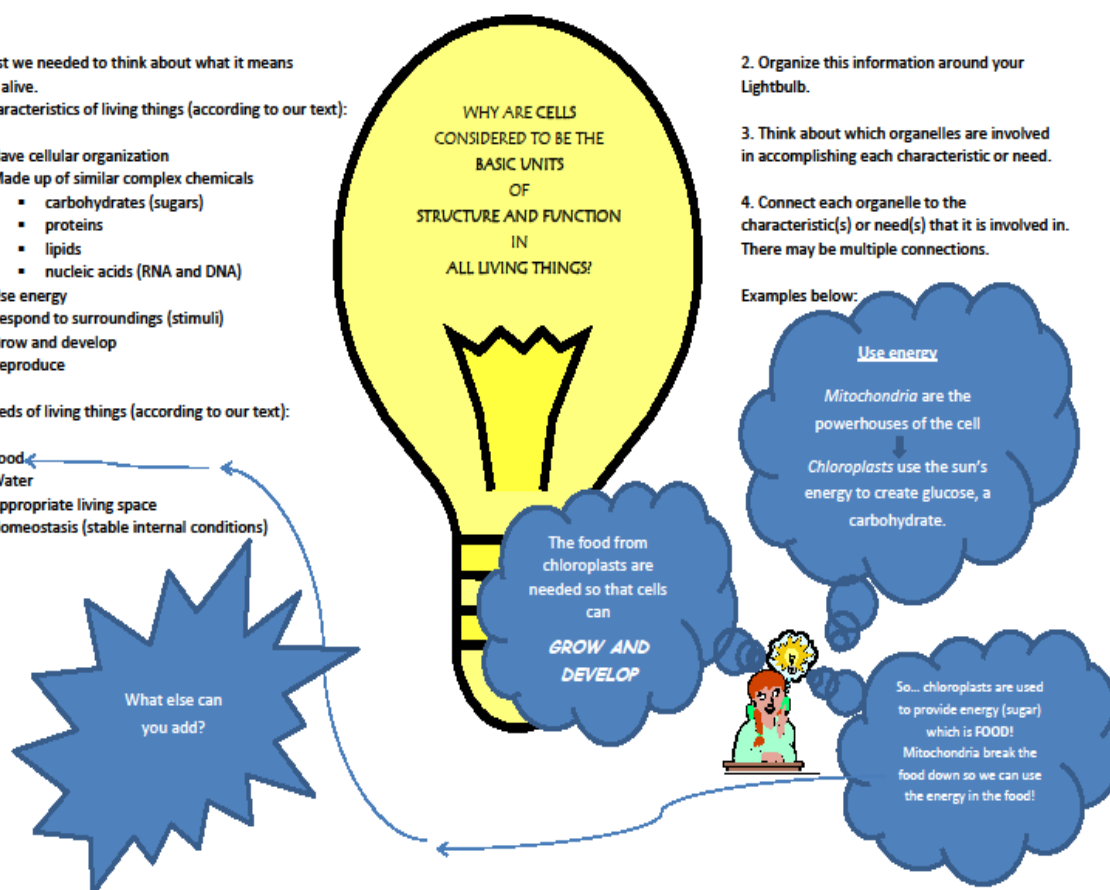
1. First we needed to think about what it means to be alive.

a. Characteristics of living things (according to our text):

- ❖ Have cellular organization
- ❖ Made up of similar complex chemicals
 - carbohydrates (sugars)
 - proteins
 - lipids
 - nucleic acids (RNA and DNA)
- ❖ Use energy
- ❖ Respond to surroundings (stimuli)
- ❖ Grow and develop
- ❖ Reproduce

b. Needs of living things (according to our text):

- ❖ Food
- ❖ Water
- ❖ Appropriate living space
- ❖ Homeostasis (stable internal conditions)



APPENDIX F

EXAMPLE OF STUDENT CREATED AHA PAGE

30

Abiotic

vs.

BioticAbiotic Factors:

- Water
- Temperature
- Soil (rocks)
- Oxygen (gases)

ecosystem -
community +
abiotic factorsBiotic system:

organism - a single living thing

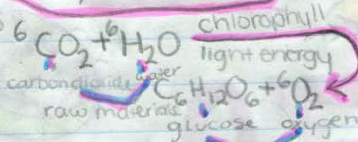
species - a group of similar organisms that can mate with each other to produce offspring that can also mate & reproduce

population - all the members of one species in an area

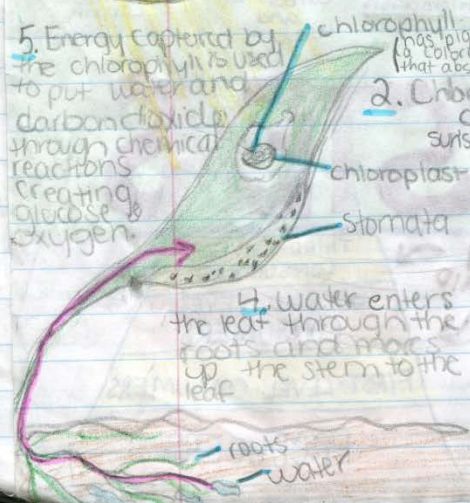
community - all the different populations that live together in an area

How
and
factors
together
Energy
an
eco-PhotosynthesisEquation of is:

1. Sun shines on leaf



5. Energy captured by the chlorophyll is used to put water and carbon dioxide through chemical reactions creating glucose & oxygen.



2. Chlorophyll capture the sun's energy

3. Carbon dioxide enters through the stomata

4. Water enters the leaf through the roots and moves up the stem to the leaf

Sun gives off virtual light spectrum
Visible light spectrum - ROYGBIV wave
red orange yellow green blue violet lengths

out of the ROYGBIV spectrum R (red) and B (blue) make plants grow best

chlorophyll in leaves reflect V (yellow) and G (green) which makes plants look the colors they are

The process of photosynthesis makes glucose and can be expressed as Kilocalories or Calories (← units)

31

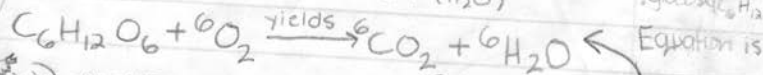
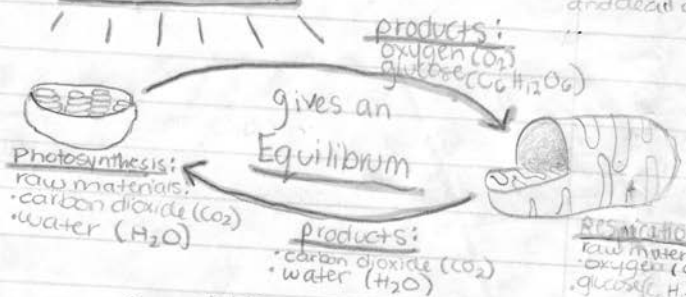
Producer

vs.

ConsumerHerbivores
eat only
plantsCarnivores
eat only meatOmnivores
eat bothScavengers
Carnivores that
feed on bodies of
dead organismsDecomposers
break down waste
and dead organic

do biotic
abiotic
work
to move
through
system?

Connection



Equation is

Respiration:6 O_2 START!
raw materialsglucose
 $\text{C}_6\text{H}_{12}\text{O}_6$ glucose
is broken
down
and moves to
mitochondria
(need oxygen) and gets broken
down to be even
smaller

END:

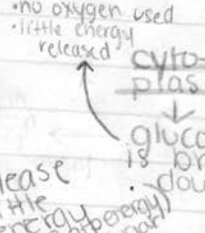
Fermentation:

• anaerobic means
no oxygen needed

2 types of fermentation:

Lactic
Acid- when your muscles
hurtAlcoholic- makes bubbles in alcoholic
beverages (ex. beer)

energy is released
(About 36 ATP
are released
that's made
per glucose)



APPENDIX G

STUDENT CREATED REFLECT AND CONNECT PAGE

4/2/13

Respiration: R & C-Respiration

the process by which cells obtain energy from glucose

V.

Fermentation: energy-releasing process that doesn't require energy

organelles involved: Mitochondria - in the 'mighty mitochondria' the powerhouse of the cell, holding the process of respiration previously broken down glucose molecules are broken down into even smaller molecules. Also, while this is happening/happens, a large amount of energy is produced (which is why the mitochondria are sometimes called the powerhouses of the cell)

Events that occur during respiration:

- Water and Carbon dioxide are created
- Cells get energy from glucose (ATP - energy cells use to carry out functions).

Process of Respiration (stages 1 and 2)

Stage 1: occurs in cytoplasm; molecules of glucose are broken down into smaller molecules; some energy is released

Stage 2: occurs in the mitochondria; small or molecules broken down in stage 1 are broken down even more through chemical reactions that require O_2 and that release a lot of energy

Sketches of the 2 stages

Stage 1: Glucose → smaller molecules (small amount of energy) Cytoplasm

Energy? plasma, glucose is broken down and a little bit of energy is produced

Stage 2: Smaller molecules → O_2 → H_2O → energy → CO_2

In mitochondria, molecules are broken down even more and a large amount of energy is produced

Basic Equation for Respiration:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$$

(and energy used by the cells - ATP)

(From the board)

Adenosine triphosphate

Adenosine PP_P

energy (in the bonds, when the bond breaks energy is released)

Equilibrium

$C_6H_{12}O_6 + O_2 \rightleftharpoons H_2O + CO_2$

ATP (for every 1 glucose, 36 ATP are released)

Cellular Respiration

The process by which cells obtain energy from glucose

Aerobic Cellular Respiration: requires O_2 releases a lot of ATP energy used by cells

Anaerobic Cellular Respiration: doesn't require O_2

Fermentation

Lactic Acid

Alcoholic

Small amount of ATP (2)

Fermentation (anaerobic cellular respiration) energy-releasing process that doesn't require oxygen

Lactic Acid: occurs when (ex.) leg muscle cells use up oxygen faster than you can produce it. CO_2 is used to replace what the oxygen energy is given to the cells.

Alcoholic: type of fermentation w/ yeast and other single celled organisms. End product is alcohol; important to bakers and brewers.

APPENDIX H

STUDENT CONFIDENCE SURVEY

Directions: Please think about who you are and answer the questions on this survey as accurately as possible. When you have completed the survey don't forget to hit *SUBMIT!*

Participation in this research is voluntary. Participation or non-participation will not affect a student's grades or class standing in any way.

I have Mrs. J for life science during period

1 2 5 6 8

I am a successful student.

Strongly agree Agree Undecided Disagree Strongly
disagree

Why did you give that answer?

I think that I am a capable student.

Strongly agree Agree Undecided Disagree Strongly
disagree

Why did you give that answer?

When it comes to school I think that I am organized.

Strongly agree Agree Undecided Disagree Strongly
disagree

I am able to find my assignments quickly.

Strongly agree Agree Undecided Disagree Strongly
disagree

I am a good problem solver.

Strongly agree Agree Undecided Disagree Strongly
disagree

When I learn something in science I can see how it applies to my life.

Strongly agree Agree Undecided Disagree Strongly
disagree

Can you think of any examples?

When we do work in science class I can see that I am building background knowledge that I will use later in life.

Strongly agree Agree Undecided Disagree Strongly disagree

Can you think of a time when you used something you learned in science class? Explain.

It is easy for me to ask for help in science.

Strongly agree Agree Undecided Disagree Strongly disagree

In science I am a strong independent learner.

Strongly agree Agree Undecided Disagree Strongly disagree

Can you think of any examples?

It is important to me that I do well in science.

Strongly agree Agree Undecided Disagree Strongly disagree

I am good at remembering important information that we've recently covered in class.

Strongly agree Agree Undecided Disagree Strongly disagree

I easily recall important information that we've covered in class a long time ago.

Strongly agree Agree Undecided Disagree Strongly disagree

I can read something in my science text and understand it.

Strongly agree Agree Undecided Disagree Strongly disagree

I can read the tables and graphs in my science text and understand them.

Strongly agree Agree Undecided Disagree Strongly disagree

It is easy for me to take notes from my science textbook.

Strongly agree Agree Undecided Disagree Strongly disagree

It is easy for me to understand the information in my textbook.

Strongly agree Agree Undecided Disagree Strongly disagree

When I take notes from my science text it helps me to understand it.

Strongly agree Agree Undecided Disagree Strongly disagree

I can use graphic organizers to show what I know in science.

Strongly agree Agree Undecided Disagree Strongly disagree

I can organize science information in a way that helps me to understand it.

Strongly agree Agree Undecided Disagree Strongly disagree

It is easy for me to understand scientific concepts.

Strongly agree Agree Undecided Disagree Strongly disagree

I am good at writing lab reports.

Strongly agree Agree Undecided Disagree Strongly disagree

Please rate how often you do the following things. Show your answer by circling the most appropriate response.

Remember, I would like you to be as honest as possible – this survey is anonymous. There is no correct or incorrect answer.

I get good grades on science tests.

Very Frequently	Frequently	Occasionally	Rarely	Never
-----------------	------------	--------------	--------	-------

I can explain the science that we're learning to other students.

Very Frequently	Frequently	Occasionally	Rarely	Never
-----------------	------------	--------------	--------	-------

I can organize the materials I need to study for science test.

Very Frequently	Frequently	Occasionally	Rarely	Never
-----------------	------------	--------------	--------	-------

I can organize the materials I need to complete a science project or lab.

Very Frequently	Frequently	Occasionally	Rarely	Never
-----------------	------------	--------------	--------	-------

I know when to ask for help in science.

Very Frequently	Frequently	Occasionally	Rarely	Never
-----------------	------------	--------------	--------	-------

In order to learn science I need someone to explain things to me.

Very Frequently	Frequently	Occasionally	Rarely	Never
-----------------	------------	--------------	--------	-------

I understand how a lab assignment connects to the science we are learning.

Very Frequently	Frequently	Occasionally	Rarely	Never
-----------------	------------	--------------	--------	-------

I need to get help to do my science homework.

Very Frequently	Frequently	Occasionally	Rarely	Never
-----------------	------------	--------------	--------	-------

I can apply the science I read in my textbook to things that happen in my life.

Very Frequently	Frequently	Occasionally	Rarely	Never
-----------------	------------	--------------	--------	-------

You are done with the survey! Don't forget to hit the SUBMIT button.

Thanks!

APPENDIX I

INTERACTIVE SCIENCE NOTEBOOK RUBRIC

SCIENCE NOTEBOOK RUBRIC

	TOTALLY AWESOME! • Your writing goes beyond basic requirements and shows in-depth understanding of concepts. • The work shows in-depth reflection throughout the learning process. • Your notebook has all required components, including dates and labels on every page. • All pages are numbered properly (even numbers on left, odd numbers on right). • R- and L-side work is correctly organized with all criteria. • The use of color and labeled diagrams/graphs enhance understanding. • The notebook is neat, complete, and organized
9	AWESOME • Your writing follows the basic requirements and shows understanding of concepts, but does not go beyond. • The work shows in-depth reflection. • Your notebook has all required components, including dates and labels on every page. • All pages are numbered properly (even numbers on left, odd numbers on right). • Right-side and left-side work is correctly organized with all criteria. • The notebook has color and diagrams are labeled. • A “9” looks much like a “10,” but it lacks the “totally” in “awesome.”
8	PRETTY DARN GOOD • The written work shows a basic understanding of concepts. • The work shows an honest but limited reflection. • Your notebook has about 90% of expected components, with dates and labels. • All pages are numbered properly (even numbers on left, odd numbers on right). • Right- and left-side work is correctly organized. • The notebook has some color; some diagrams are labeled. • Some requirements are met, but your notebook lacks criteria in all areas.
7	KICK IT UP A NOTCH • The written work shows a limited understanding of concepts. • The work shows limited overall reflection. • Your notebook has about 80% of expected components, with dates and labels. • Most pages are numbered. • Right - and left-side work is somewhat organized. • The notebook has little color and few diagrams. • Requirements are rarely met.
6	GET YOUR HEAD IN THE GAME • The written work shows misconceptions and/or a lack of understanding. • The work shows little or no reflection. • The pages in the notebook are unfinished. • Dates and labels are missing on at least half of the pages.

	• There are inconsistencies in the right- and left-side work. • The notebook is disorganized and missing at least half of the required criteria.
5	UNACCEPTABLE FOR MIDDLE SCHOOL WORK • You turned in a notebook, but the pages are mostly blank. • You need to catch up and get your notebook up to speed if you want to be successful.

Adapted from:

Teaching Science With Interactive Notebooks, by Kellie Marcarelli. Thousand Oaks, CA: Corwin. *Reproduction authorized only for the local school site or nonprofit organization that has purchased this book.*

APPENDIX J

TEACHER FIELD AND REFLECTIVE JOURNAL TEMPLATE

Teacher Reflective Journal Rubric

Date:

Treatment/Non-treatment

Unit:

Topic/Activity:

Observation (research question)	Question or topic	Tally number of correct responses	#	Total: #/n
Question on Content (PAR)				
Number needing direct instruction for R&C (Sub1)				
Number observed helping others with R&C (Sub1)				
Number of engaged students (Sub1)				
Number of written corrections made (Sub2)				
Number of correct verbal explanations (Sub2)				

Written Prompts:

- What went well today?
- What did not go well?
- If things did not go well – why?
- What can I do to improve?
- Examples of student engagement
- Examples of student frustration
- Specific student comments
- How did I feel about today's lesson?

Weekly overview

How well did students appear to understand the content taught this week?

Provide evidence.

Unit Summary

Observation (research question)	Question or topic	Tally number of correct responses	#	Total: #/n
Question on Content(PAR)				
Number needing direct instruction for R&C(Sub1)				
Number observed helping others with R&C(Sub1)				
Number of engaged students(Sub1)				
Number of written corrections made(Sub2)				
Number of correct verbal explanations(Sub2)				