EVALUATING THE EFFECTIVENESS OF A BLENDED SCIENCE UNIT IN A RURAL, SINGLE-CLASSROOM SCHOOLHOUSE

A Project

Presented

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by

Mikki Westbie

Summer 2010

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DEDICATION

This project is dedicated to my mother, Barbara Westbie, and my grandmother, Virginia Thompson. Your love and support have enabled me to complete this “never-ending project” despite life’s challenges: I love you and am eternally grateful for the blessings you have brought into my life.

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ABSTRACT

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This project consists of two parts: (1) the development of a blended science unit composed of interactive online and hands-on classroom curriculum and (2) a case study documenting the effects of this unit on a teacher's confidence and perception about teaching science; making future curricular decisions; and student learning. Data was collected using a mixed methods approach and included observations, interviews, journals, surveys, and pre/post content tests. Results were mixed: The teacher became more confident about her ability to teach science and had an increased interest in adding online and hands-on content. Yet she became less confident that her teaching would significantly impact student learning, and chose to return to a teacher-centered instructional approach for a large portion of the unit in response to persistent classroom challenges. Students had statistically significant gains in learning on a standardized test, but these gains were modest and consistent with superficial knowledge acquisition rather than deep conceptual understanding. The paper concludes with a discussion about how conflicting theoretical views about curriculum as “reference material,” held by the teacher, and curriculum as a “partnership” held by the researcher, led to unanticipated differences in the way the unit was implemented.

CHAPTER I

INTRODUCTION TO THE PROJECT

Purpose of the Project

The purpose of this research project was to evaluate the effectiveness of a blended science unit, including laboratory (hands-on) and online (web-based) activities, on teaching and learning in a rural, single classroom schoolhouse.

A blended science unit was created for use with upper elementary grades; the ecology unit was then tested for effectiveness in a multiple-subject, multiple-grade classroom using a case study protocol.

While the learning unit delivered both instructional and direct science content, the case study was designed to determine its efficacy: What effects would using the blended unit have on the teacher's perceptions about and confidence in teaching science; what impact would the design and content of the unit have on the teacher's future curricular decisions; and how effective would the blended unit be in teaching the desired concepts?

Learning Unit

The ecology unit consisted of an eight-week, interactive, series of hands-on and web-based lessons. The scope and sequence, background information, laboratory and online activities were accessible to the teacher and students via the researcher's published web site "Energy through the Ecosystem." The coursework aligned with

California content standards (Grades 4-6; Bruton, S. & Ong, F., 2000), and was adaptable for Grades 1-8. The content also conformed to district (North American Division Office of Education, 2009), national (National Committee on Science Education Standards and Assessment, 1996) and online (North American Council for Online Learning, 2007).

Case Study

To determine the effectiveness of the blended unit, a case study was conducted at a small, rural, faith-based, K-8 elementary school in Northern California.[1] Across the entirety of the case study, the school had 10 students and served four families. Due to disenrollment (one student), new enrollment (two students), and illness (one student), six of the original students and their teacher completed all parts of the learning unit and data collection process and thus were included in the case study. The students attended grades 2 to 7, with vertical advancement and remediation allowed across subject areas to accommodate differing proficiencies in, for instance, math and reading. The teacher, Mrs. D., is credentialed as both an elementary teacher and child development program director; has advanced training in special education; and is currently matriculating an administrative degree. She has been teaching for six years; this was her second year at the participating school.

Multiple methods of data collection were employed in the case study, including: Non-participatory observations and participant observations; face-to face, telephone and focus group interviews; and document acquisitions, e.g., questionnaires, journals, and pre/post content tests.

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[1] Identifying information pertaining to the school, students and teacher have been masked to protect participants' privacy.

Background

The idea of a one-room schoolhouse conjures up visions of the 19th century American West as depicted in classic westerns and epitomized in the 1970's television series, *Little House on the Prairie*. In the 21st century, we are apt to visualize a Western elementary school as an amalgam of blocky buildings and portable trailers serving children separated into discrete classrooms, like cells in a beehive, according to grade level. The one-room, multiple grade schoolhouse is relegated to quaint memory.

But this impression would be wrong. While the architecture may have changed, the single-classroom, K-8 schoolhouse remains a vital educational link for many rural communities (Miller, 1991; Swindler, 1995). The sole educator, who may also assume the role of school's principal, is responsible for providing meaningful, differentiated, standards-aligned curriculum for each student in the class (Mrs. D., personal communication, April 2, 2009).

While elementary teachers are widely admired for their ability to provide differentiated curriculum across multiple subjects, the lone teacher in this type of rural school faces the daunting addition of giving vertical instruction to multiple grades, thus intensifying an already challenging assignment. Having no on-site colleagues with whom to plan, develop, or modify curricula, the teacher alone is responsible for obtaining, creating, researching, or otherwise preparing lessons for a minimum of six different subject areas and up to nine grade levels per day. This translates to nine separate, meaningful lessons (or nine levels of differentiation for one class-wide lesson) for every day science is taught in the classroom. For teachers who follow the National Science Teachers Association (NSTA) recommendation that children receive daily access to inquiry science at every grade level (2002), this amounts to 45 inquiry-based science lessons per week.

Such a workload would be a struggle for teachers who have a science degree and teach this subject exclusively. For educators teaching multiple subjects, and especially for those without a strong background in the sciences, the task would be substantially more difficult. But for an elementary teacher teaching multiple subjects to multiple grades, creating meaningful science curriculum at the recommended scale would entail a herculean effort.

Context of Current Research

Mrs. D, a teacher/principal in a rural, faith-based, single-classroom schoolhouse in Northern California, faced the same demands and obstacles encountered by other elementary teachers (Dorph et al., 2007). In addition to teaching multiple subjects, however, her classroom consisted of seven grades; therefore, instructional planning for each subject was seven times more demanding than the already immense workload experienced by other elementary teachers. Mrs. D. was responsible for implementing the educational program, including: Choosing and providing meaningful, differentiated, standards-aligned curriculum and assessments; administering standardized assessments; coordinating parent volunteers and guest teachers; and meeting the physical, emotional and spiritual needs of each student (Mrs. D., personal communication, July 7, 2009). Perhaps even more than her national counterparts, Mrs. D. was pressed for time.

Furthermore, Mrs. D. was the school's principal. In her role as administrator, she was responsible for coordinating all phases of the school's operation, including: Administrative tasks; budgetary planning and reconciliation; community outreach and parental involvement; student discipline and counseling; and educational program design (Mrs. D., personal communication, July 7, 2009).

Student-centered instruction was Mrs. D's forte; a former special education teacher, she was skilled at providing differentiated and individualized lessons for her students. However, the voluminous subject matter knowledge and curricular material required for her to sustain six subjects a day was taxing. In addition, while she enjoyed teaching science, she was not confident in her ability to teach this subject effectively.

Variety and flexibility. This learning unit was created to respond to the time, proficiency and resource concerns of Mrs. D and other elementary teachers (Dorph et al., 2007). It adopts a pragmatic approach: When in doubt, add variety to reflect the diverse needs of different students, instructional strategies, and educational settings. Students think and learn differently at different ages, and have diverse academic needs that reflect the continuum of cognitive development (DeVries, 2005). Some children need ample guidance from the teacher, while others feel shackled by this attention but thrive on their own. Moreover, during a given lesson the entire class may need more or less leadership (Perkins, 1992). Employing a variety of instructional strategies, then, makes pedagogical sense.

This strategy has been validated by the National Research Council: After reviewing multiple empirical studies related to pedagogical approaches, instructional strategies and learner support, the council opined that structuring a variety of learning experiences is the most effective instructional approach to support students in achieving and retaining scientific literacy. The council recommended the application of strategies from all along the pedagogical continuum, from teacher-directed to learner-centered, that includes ample hands-on and “minds on” opportunities (NRC, 2007).

As a multi-modal approach is time consuming and demanding for educators to design (Hooft, 2005), this project sought to mitigate those challenges by providing a multi-modal, “packaged” life science learning unit that could be used “out of the box” or easily modified according to instructional needs.

In order to establish reasonable parameters for the design process, the California life science content standards for public school students in Grades 4 through 6 were chosen as boundaries (Ong & Lundin, 2004). The unit was also designed to readily expand to upper and lower grades and to students of differing capabilities.
This was especially advantageous for Mrs. D.’s class.

While substantially comparable, the grade level content standards for Mrs. D.’s private district varied from public school standards (California Department of Education, 2009). While private schools must teach the same areas of study as public schools, the California Education Code gives broad parameters for the adopted course of study, i.e., grades K-6 (education code 51210) and 7-12 (education code 51220), rather than the grade-specific standards that apply to public schools (http://www.cde.ca.gov/sp/ps/rq/psaffedcode.asp). For instance, according to the district’s Key Learnings, food chains and food webs should be fully described in third grade while in public schools they should be introduced in fourth grade, and reexamined in sixth grade. Similarly, the study of photosynthesis is scheduled one grade apart; while this subject is addressed in fourth grade in this district, it is studied in fifth grade in the public school system.

Moreover, some students in Mrs. D.'s class were known to perform either above or below grade level in science; the teacher required lesson plans that were not grade-level contingent, but that were implementable in a meaningful way at diverse grades and student maturation levels. For her part, the educator was charged with adding content for very young learners, as well as identifying enrichment activities for the oldest learners.

Scope of the Project

This project consisted of an eight-week, interactive, blended science unit and a case study of the class in which the learning unit was tested. The intended audience for the unit and case study is composed of elementary teachers and curriculum specialists, especially those tasked with teaching and/or designing curriculum in rural schools that utilize multiple-level classrooms. It is hoped that the project will provide both a curricular resource and research data to assist in future curricular decisions.

Design: Learning Unit

The classroom and online components of the blended unit employed the ecological concept of interdependence (the idea that organisms depend on each other and the environment for survival) to introduce students to photosynthesis; deepen prior knowledge of food chains; and extend this understanding to more complex food webs. Students then applied their new knowledge and skills to the exploration of an online ecosystem. The life cycle and migration of Monarch butterflies provided a real-world, *citizen science* investigational thread to further support conceptual understanding and add immediate relevance to the learning experience.

The online portion of the unit was designed as a student-directed, interactive sequence of activities that encouraged pupils of differing grades and competencies to proceed at their own pace while exploring the ecological concepts presented. Due to the scaffolding needs of the participating learners, concepts were presented sequentially. Students initially explored the flow of energy through photosynthesis, then through food chains and food webs. Learners applied these principles to Monarch butterflies, a known representative organism and finally tested their mastery of the subject matter by applying the concepts to a novel ecosystem not previously studied.

As previously noted, the online and classroom lessons formed a blended unit. In the integrated lesson sequence each component of the unit was designed to complement the other; for instance, photosynthesis lessons included a multi-week plant experiment and other class activities, as well as interactive online sessions. Through the online portal the teacher was provided with instructional resources for the unit, including: An eight-week recommended scope and sequence; subject matter backgrounds; lesson plans and handouts for in-class lessons and activities; additional optional activities and resources; and complete lessons for student-centered laboratories to align with the web-mediated portion of the curriculum. The learning unit is published at http://web.me.com/mwestbie/energy.

<u>Design: Case Study</u>

Data was collected using a case study approach and included multiple measures such as observations, interviews and document acquisitions. Observations of the teacher and students from the side of the classroom were augmented by participant observations during labs and online sessions. In the latter case the researcher also acted as a technical advisor for teacher questions about the science content, and as technical support for students encountering computer problems. Pre-study teacher interviews, both in-person and telephonic, occurred over a three-month period as the learning unit developed; in addition, the researcher consulted Mrs. D. informally to adjust content to meet her needs. Informal conversations with the teacher and students transpired throughout the implementation of the unit as needed to meet immediate learner needs and other contingencies such as computer malfunctions. Focus group interviews were completed with the participating students and a terminal interview was conducted with Mrs. D. at the conclusion of the study.

A variety of documents were collected during the case study. To evaluate student learning goals, pupils completed pre and post content tests. In addition, they were asked to submit reflective journal entries for each activity as a fluid normative assessment of conceptual understanding as well as a measure of interest in a given lesson. The teacher completed pre- and post-unit perception surveys, a post-unit evaluation of materials, and was asked to keep a reflective journal pertaining to lessons taught.

Goals of Learning Unit

The following learning goals shaped the design of the blended learning unit:

- Students will understand that most life energy originates as sunlight and is transformed into chemical energy by plants through the process of photosynthesis; chemical energy flows throughout the biotic system through food webs.
- Students will understand that photosynthesis is the process by which plants and some other organisms, known as primary producers, use the energy of sunlight to manufacture food that forms the base of most food chains.

- Students will understand that the richness of plant growth is integral to the number and diversity of organisms that can be supported in an ecosystem.
- Students will understand that organisms are dependent on each other and their environment, and thrive when all components of the ecosystem are balanced; conversely, the ecosystem may be harmed when one or more components are out of balance.
- Students will understand how a representative organism, the Monarch butterfly, interacts with and depends upon the ecosystem.

Website uniform resource locators (urls) for applicable national, state, district, and online learning standards are listed in the References section.

Goals of Case Study

While the curriculum unit was designed to address the learning goals elucidated above, four research questions and attending hypotheses gave structure to the case study:

Question 1. What effects will using a blended science unit have on the teacher's confidence about teaching science content? This aspect of the research sought to determine whether there would be a change in the teacher's self-assurance regarding content knowledge and ability to explain concepts to learners. It was hypothesized that Mrs. D. would benefit from a packaged learning unit because she would have access to a cohesive curriculum unit modified to support her teaching.

In addition, the unit offered multiple resources, such as background reading and website links, by which to increase her content knowledge in anticipation of teaching the unit material. In an initial interview Mrs. D. had expressed concerns about her content knowledge: "Science is my second-to-worst subject. Math is my worst. I'm really good at teaching social studies" (Mrs. D., personal communication, April 2, 2009). However, she was clearly motivated to increase her conceptual knowledge and ability to transmit core concepts; this was evidenced by unreserved cooperation in the development of the unit, as well as "practicing" the online content and asking concept-related questions in advance of student exposure to the material. Thus, it was anticipated that having access to science resources as well as the researcher to answer clarifying questions throughout the course of the unit would increase Mrs. D.'s confidence in teaching the proffered concepts.

Question 2. What effects will using a blended science unit have on the teacher's perceptions about teaching science? This area of inquiry sought to determine whether the unit would encourage the teacher to change her perception of best practices in the teaching of science, incorporating more hands-on instruction as opposed to direct instruction, and incorporating more technology in the classroom in a blended way. It was hypothesized that Mrs. D. would benefit from a blended unit because it offered her flexibility. This flexibility would enable her to address immediate classroom logistical problems (such as a diverse set of learners spanning Grades K-8, limited material resources including computers, and limited time) while allowing her to experiment with new teaching styles in a safe environment.

For Mrs. D., flexibility between classroom instruction and online instruction is of primary concern for two reasons. First, Internet access was periodically interrupted by outside influences: For instance, area-wide upgrades by the telephone company had caused intermittent loss of telephone and broadband service during the researcher's pre-project visits; such interruptions were expected to occur periodically for the next several months until the utility's work was completed. Thus, the unit included meaningful classroom activities that could be used during unexpected losses of Internet capabilities and that avoided inconsequential "seat work" designed primarily to fill time and keep students occupied.

Second, there were a limited number of student computers, necessitating the flexibility for the teacher to work with one group of students while another group accessed the online portion of the unit. The combination of hands-on and web-based activities in the unit reduced the strain on the limited computer resources. The scope and sequence of the unit was specifically written to address this concern, as it was expressed to the researcher during casual conversation at the time of the first pre-project classroom visit.

Question 3. Will the design and/or the content of the unit affect the teacher's future curricular decisions? This segment of the investigation sought to determine whether exposure to the blended unit model, as well as the content embedded into the unit would influence Mrs. D.'s future decisions regarding curriculum. As the school's administrator as well as the teacher, she is responsible for evaluating science textbooks, equipment and other curricular materials. It was hypothesized that experience with the unit would: (1) persuade Mrs. D. to substantially increase the amount of online curricula; and (2) add citizen science (public participation in scientific research) projects to the science schedule.

Prior to the unit, Mrs. D. allowed computer access for research, reward, and math and language arts remediation and enhancement. Due to unreliable computer hardware at school and inconsistent access at students' homes, the teacher was unwilling to rely on this media in any larger capacity. It was expected that once Mrs. D. experienced the adaptability of the blended unit to mitigate the impact of computer problems on the science sequence she would be willing to risk adding online technology to the curriculum.

Moreover, it was hypothesized that Mrs. D. would add citizen science projects to the curriculum. The educator already employed real-life activities to motivate students and integrate subjects within the curriculum; the unit introduced her to a type of real-world science in which her students could participate. Both Mrs. D. and her students showed immense interest in “Monarch Watch,” one such citizen science project, during the Spring 2009 pre-project interviews. It was this project that was incorporated into the blended science unit.

Generally, the unit afforded Mrs. D. the opportunity to explore different facets of blended units, including using computers as technology; increasing the number of hands-on activities; and incorporating peer teaching and citizen science to make the content more meaningful to students. Thus, it was anticipated that exposure to the blended unit would influence future curricular decisions.

Question 4. How effective is the blended unit at teaching the desired concepts? While the other research questions focused on the educator’s use of the unit, this area of inquiry was concentrated on the efficacy of the unit itself. It was hypothesized that students would learn the desired concepts because the material was offered in a variety of ways in order to meet diverse learning styles; for instance, classroom activities utilized reading, pictures, discussion and hands-on approaches, while online content was accessed using video, audio, and interactive media.

Furthermore, the science content was adapted from a variety of vetted sources, many of which are well regarded and commonly consulted by the teaching community such as Nova, Teacher's Domain and the Web-Based Inquiry Science Environment (WISE). Furthermore, content was added to the unit only if two or more sources were in agreement on the concept addressed; for example, one published food web showed arrows going "down" the food chains; by checking with multiple resources the errors were clear and the content was not used in the proffered curriculum unit. All components of the unit were vetted in a similar manner.

Significance of the Project

This project is significant because it adds to the body of knowledge in an area of science education in which there is a shortage of research data. While there are many scholarly articles about blended, or hybrid, learning as a pedagogical approach, studies of blended learning in the classroom have been concentrated on post-secondary education (see for example Rovai, 2004). Moreover, those studies have focused primarily on course-level choices, i.e., whether or not or to what extent a particular course utilized both face-to-face and online components in its overall design, and how these choices affected student learning (see for example Ausburn, 2004; Lynch & Dembo, 2004).

In contrast, the current project was sited in a primary rather than post-secondary learning environment and focused on a learning unit rather than an entire course. A survey of major online teacher curriculum databases, including: WISE, Ecology WWW, and the National Science Digital Library (NSDL), revealed a dearth of blended science units for elementary students that teach ecological principles in the manner of this project. The researcher was unable to locate scholarly research that evaluated blended science units in the elementary classroom.

Moreover, the current case study was conducted in a single classroom schoolhouse, a unique environment among elementary schools. The small amount of contemporary research pertaining to pedagogy in this type of school, such as the ethnographic analysis conducted by Swindler (2005) in one of Nebraska's remaining one-teacher schools, has been concerned with emergent pedagogy and the benefits of a small-school setting rather than with particular curricula. Thus the current project, having an emphasis on specific content within the science curriculum and the empirical study of its effectiveness within the unique educational setting of the single classroom schoolhouse, fills an apparently vacant niche within the greater body of current knowledge. A complete discussion of the search criteria and broader research parameters applicable to this study is included in the Literature Review.

Limitations of the Project

The primary limitation of this project was the small test population: One teacher and 10 students piloted the learning unit; of this group, the teacher and six children completed the entire unit and thus participated in the case study.

An additional limitation was related to technology. The success of online learning is predicated on adequate technical infrastructure, teacher computer competence, and timely technological support. While some components of the unit are designed to be used offline in classroom activities and laboratories, the distinctiveness of this resource is based upon the unit's blended construct. Over the course of the study three of the four student computers experienced technical difficulties: Four weeks into the study one machine crashed and when restarted would not access the web site. A second crashed and was inaccessible for one week. A third computer would not run Java, a program necessary for some online content; despite repeated attempts to download and install the program, the computer would not accept the software application and offered limited research benefit for the entire length of the study.

Definition of Terms

Acronyms

CADOE: California Department of Education

NACOL: National Association for K-12 Online Learning

NAEP: National Assessment of Educational Progress

NCLB: No Child Left Behind Act

NRC: National Research Council

NSDL: National Science Digital Library

NSTA: National Science Teachers Association

PISA: Program for International Student Assessment

STAR: Standardized Testing and Reporting

TIMSS: Trends in International Mathematics and Science Study

USDOE: United States Department of Education

WISE: Web-Based Inquiry Science Environment

Definitions

- Blended Unit: Also called a hybrid unit; a learning unit composed of web-based and classroom-based lessons that incorporate multiple learning modalities.

- Citizen Science: Also known as public participation in scientific research; a term used for projects or ongoing programs of scientific research in which non-scientist volunteers perform or manage research-related tasks such as observation, measurement or computation. Data is often submitted and collated online.

- Key Learnings: The content standards of the Seventh-day Adventist North American Division Office of Education.

- National Association for K-12 Online Learning (NACOL): The national chapter of the International Association for K-12 Online Learning, a non-profit organization that facilitates collaboration, advocacy, and research to enhance quality K-12 online teaching and learning.

- National Assessment of Educational Progress (NAEP): A United States Department of Education report that serves as the national, continuing assessment of American students' content knowledge and skills in a variety of subject areas.

- No Child Left Behind Act (NCLB): Public law 107-110, a 2001 reauthorization of the Elementary and Secondary Education Act (ESEA), the main federal law affecting education from kindergarten through high school. The law mandates standards-based education and achievement testing for all students.

- Program for International Student Assessment (PISA): A system of international assessment of 15 year old student performance that measures reading, mathematics, and science literacy. The assessments measure functional skills such as cross-curricular competency.

- Standardized Testing and Reporting (STAR): A California program that administers annual subject matter achievement tests; the results are used for student and school accountability purposes.

- Trends in International Mathematics and Science Study (TIMSS): A United States Department of Education publication that provides data on the mathematics and science achievement of American fourth and eighth grade students as compared to that of students in other countries.

CHAPTER II

LITERATURE REVIEW

In preparing the literature review several educational, professional and statistical databases were consulted, including: Academic Search, ERIC, PsychINFO, SpringerLink, Google Scholar, California Department of Education, U.S. Department of Education, International Council for Online Learning, American Association for the Advancement of Science, and National Center for Education Statistics, as well as professional journals and published university collections.

Science education is a dynamic discipline that strives to enhance children's innate curiosity and provide them with the tools to explore, document and explain the natural world and their place in it. There is evidence, however, that many students do not possess sufficient proficiency in science. As described in *Taking Science to School,*

> Proficiency in science involves having knowledge of facts and concepts as well as how these ideas and concepts are related to each other. Thus, to become expert in science, students need to learn key ideas and concepts, how they are related to each other, and their implications and applications within the discipline. This entails a process of conceptual development… and is not a simple accumulation of information. (NRC, 2007, p. 338)

Standings

As a nation, American science literacy ranked among the top ten on the science portion of the 2007 Trends in International Mathematics and Science Study (TIMSS), an international comparison of discrete content knowledge. According to the 2007 TIMMS (Gonzales et al., 2008) report, fourth grade science students placed fifth, and eighth grade students placed tenth, in relation to students from other participating countries.

While this is a respectable ranking, there remains widespread dissatisfaction with student achievement among parents, policymakers, legislators and educators (National Science Board, 2004). According to the latest published Program for International Student Assessment (PISA) research (2006), American students ranked twenty-second among their international counterparts in the ability to apply scientific principles to problems in a real-world context. Using this measure of scientific literacy, the United States placed in the bottom third of participating nations (Baldi, Jin, Skemer, Green, & Herbert, 2007). This suggests that while American students perform well on standardized tests like that used in the 2007 TIMMS study, their understanding of science is superficial, and is limited to memorization as compared to deeper conceptual understanding.

In fact, this “mile wide, inch deep” problem in American science literacy is likely a result of the textbooks and curriculum that is currently adopted in most schools. An evaluation of nine widely used American textbook series by the American Association for the Advancement of Science (AAAS) Project 2061 found that programs universally fail to focus on key ideas:

> Programs are particularly deficient in providing coherent explanations of real-world phenomena using key science ideas, and building on students’ existing ideas or helping them overcome their misconceptions or missing prerequisite knowledge. No program received a satisfactory rating for these criteria. (Kesidou et al., 2002, p. 538)

A comparison of the curriculum across the top ten nations in the 2007 TIMMS study prompted similar condemnations of American curricula as unfocused and not coherent in the attempt to cover too much material. Consider for instance that the average fourth grade textbook in America is 397 pages long, compared to the international average of 125 pages (Valverde & Schmidt, 1997). With such curricula in our schools, low science proficiency as revealed in the PISA report is hardly surprising.

A national cross-state comparison of science achievement is especially disheartening for California students and educators: The most recent National Assessment of Educational Progress (NAEP) showed that both fourth grade and eighth grade California science students ranked second-to-last against their national peers. While the average scale score (the measurement used for ranking purposes) had risen eight points since the prior (2000) study, California's rank remained relatively unchanged (NAEP, 2005). Using California assessment standards, less than half of fifth grade students and just barely over half of eighth grade students demonstrated satisfactory science achievement (according to the 2008 Standardized Testing and Reporting [STAR] science results). At the opposite end of the spectrum, the science literacy of 9% of fifth grade students, and 15% of eighth grade students, was considered "far below basic" (http://star.cde.ca.gov/star2008/Viewreport.asp).

Challenges

What accounts for such a dismal showing in California? According to Dorph et al. (2007), San Francisco Bay Area teachers reported multiple hindrances to science education, including: Limited time, limited proficiency, limited resources and limited funding. These findings were echoed at the national level. One California county-level Science Coordinator summed up the regional science conundrum in the following way:

> Science instruction? The typical distribution in our county, a couple teachers love science and teach it, a few will teach because they feel they should, another few will pass out the science textbook and read from it, and some will sneak by without any science. (Dorph, et. al, 2007, Voices of Educators section, para. 1)

Limited Time

Perhaps the greatest challenge for educators has been time: Districts in the San Francisco Bay Area study cited the enactment of the No Child Left Behind (NCLB) Act, with its emphasis on mathematics and reading/language arts, as a driving force for the decline in time spent on classroom science. Elementary teachers in the Bay Area study spent an average of 60 minutes on science during the school week, compared to a national average of 125 minutes reported in 2000, a year before NCLB was passed. Furthermore, 16% of students received no science instruction at all, principally at schools labeled Program Improvement under NCLB (Dorph et al., 2007, Limited Time for Science section).

Even without the specific requirements of NCLB, however, the problem of time remains. In a political climate that appears to hold educators solely responsible for student achievement, ”teachers need to modify and adapt curriculum materials so as to design instruction that is appropriate for a particular group of students at a particular time” (NRC, 2007, p. 344). That requires time to analyze research data, determine the best pedagogical approache(s) for their classrooms, and design appropriate curricula.

Unfortunately, time is in short supply. Klahr & Li (2005) found that while teachers can “make it [the curriculum] work,” they often cannot analyze “why it works”:

> A teacher’s task is more like that of an engineer than a scientist. The available components are products like curricula, textbooks, teaching guides, and training workshops…the teachers’ primary goal is to “make it work.” Seeking “why it

> works" usually requires additional time and energy that overburdened teachers can ill-afford. (Klahr & Li, 2005, p. 220)

Limited Proficiency

A further reason Dorph et al. (2007) cited for the lack of time spent on science is that elementary teachers have had inadequate preparation and training to teach science. Forty-one percent of the surveyed multiple-subject teachers felt under-prepared to teach science content; by comparison, only 4% perceived themselves as under-prepared to teach reading/language arts and mathematics, the two subjects deemed the cornerstone of educational reform through NCLB. Though science resource teachers were better prepared, 16% of those content specialists also perceived their skills to be inadequate (Dorph et al., 2007, Limited Teacher Preparation section). The NRC pointed out that this is a national, rather than regional, shortcoming: "…teachers must understand the science they teach broadly and deeply....[t]his broad understanding of science is not readily supported by the typical undergraduate science courses provided for aspiring teachers" (NRC, 2007, p. 344).

While widespread structural deficits in undergraduate education are only correctable at the university and professional development levels, having access to science resources can help teachers better understand concepts they are teaching on a day-to-day basis. The current project was designed to enhance teachers' conceptual understanding of the life science topics presented by including background material and a variety of online resources, as well as access to a science educator.

Limited Resources and Funding

Finally, county Offices of Education in the Bay Area asserted that funding for professional development to increase content knowledge and science-specific pedagogical skills had been inadequate. Fifty-two percent of respondents also reported that their district offices lacked the capacity to support science education (Dorph et al., 2007, Inconsistent & Inadequate Capacity section). In making recommendations for future policy decisions, the NRC asserted that elementary teachers should receive "science-specific professional development…rooted in the science that teachers teach," including science content, current research about the way children learn science, and how best to teach this subject (NRC, 2007, p. 350). The council further recommended that Federal funding to providers of professional development be designed so as to require applicants to support these core areas. Unfortunately, even with funding science receives a disproportionately small amount of in-service training time. The U.S. Department of Education reported:

> Over the course of the 2005–06 school year and summer, elementary teachers averaged 11.7 hours on the in-depth study of topics in the subject of reading and only 5.9 hours on the in-depth study of topics in mathematics. They averaged 5.9 hours on professional development focused on *all other academic subject areas* [emphasis added]. (USDOE, 2009, para. 17).

Misconceptions

Much research has been published about *misconceptions, preconceptions,* and other "errors in thinking." A thorough review of the literature is prohibitive; the sheer volume of such work is daunting and beyond the scope of the current project. However, it is necessary to identify misconceptions that relate directly to the scientific content in the curriculum unit.

Students approach learning with prior knowledge derived from personal experiences (Matthews, 1997). In some instances, the application of prior knowledge to a scientific concept creates an incorrect notion about the topic under consideration. One such misconception relevant to this learning unit is that heat from the sun drives photosynthesis (Berthelsen, 1999); similarly, students believe that the main job of a leaf is to capture the warmth of the sun (Wandersee, 1986).

This is not an unreasonable idea. Children see plants grow and bloom in the spring and summer; in Northern California, they often help set seed and maintain prolific household vegetable gardens and family farms, thereby witnessing the abundance of life when the weather is warm. Conversely, they observe plants wither and “die” in the fall and winter when the weather turns cold.

A second misconception pertinent to the unit is the idea that an increase or decrease in one organism population along a food chain will affect only other organisms on the same chain, not those along a different energy route. This is especially true for organisms sitting a distance away in the same food web (Griffiths & Grant, 1985). As a food web constitutes an invisible network of complex predator/prey relationships, a lack of recognition of this effect is not necessarily surprising; however, the researchers found that students also think that some organisms in a food chain are unimportant and therefore a change in their numbers is inconsequential to the food web. Like notions about photosynthesis, everyday experience may account for this view: Bacteria, fungi and insects are anathemas; birds and mammals are familiar and thus perceived as more critical and central in a food web.

The lessons in the blended learning unit were selected to address these misconceptions using both online and classroom activities. In addition, lesson plans provided the teacher with background information and suggestions on ways to assess the development of revised conceptual understanding.

Pedagogical Approaches

The proffered blended learning unit strove to combine the recognized strengths of hands-on and online learning approaches while mitigating known limitations inherent in each strategy.

Hands-on Learning

Hands-on learning has been considered an important component of education since the 1860's, and science education since the 1960's (Hodson, 1990; Tobin, 1990). Over forty years later, this approach continues to be an educational mainstay: According to the NSTA, students should have access to science every day and multiple opportunities for laboratory activities every week (2007). For California students, the Department of Education recommends that "hands-on activities compose at least 20 to 25 percent of the science instructional time in kindergarten through grade eight" (Ong & Lundin, 2004, p. 11).

Benefits. Hands-on, or laboratory, activities are important for several reasons. When used properly, the science lab allows students to develop and deepen their understanding of natural science concepts and improve science inquiry skills

(Hofstein & Lunetta, 2003); promote appreciation of the natural world and our place in it; and develop social skills such as cooperation and communication that will carry forward to new educational environments, thereby creating valuable future experiences (Dalke et al., 2007). In addition, hands-on activities are frequently more engaging than direct instruction and pencil-and-paper lessons.

Limitations. The AAAS warns, however, "Hands-on experience is important but does not guarantee meaningfulness. It is possible to have rooms full of students doing interesting and enjoyable hands-on work that leads nowhere conceptually" (2009, para. 53). Rather, laboratory activities contribute most to learning when they are part of an integrated, well-thought-out plan for learning over time (Klahr & Li, 2005).

Coordinating and facilitating meaningful hands-on lessons place a heavy burden on the teacher, both in time and resources (Hofstein & Lunetta, 2003).
As previously discussed regarding general science instruction, time is a commodity in short supply for many elementary teachers. In addition, lab supplies and equipment are costly and often inadequate to meet learner needs: "The problem is most notable in elementary schools, where, in some cases, teachers and students do not have access to even the most rudimentary tools and materials necessary for teaching and learning science" (Moreno, 1999, p. 572).

Online Learning

Online learning, in which students complete some or all of their coursework through an Internet connection, is rapidly becoming a mainstream pedagogical strategy. According to the 2008 data findings in the national annual Speak Up online survey, 44% of sixth through twelfth grade students thought that online courses will have the greatest positive impact on their learning. This is a 3% growth in this perception from the prior year and a 20% increase over the 2006 survey. Furthermore, 49% of high school students, 39% of middle school students, and 25% of elementary students cited personal control of learning as a primary reason they believed this approach to be a valuable resource (Project Tomorrow, 2009). Unfortunately, most scholarly studies of curriculum efficacy to date have focused on post-secondary education. Of the K-12 research available, several benefits and limitations have been noted.

Benefits. A well-known benefit of having computer access at school is that learners have the ability to tap vast stores of digital information available on the Internet. But the virtual world of web-based activities and computer simulations offers science students other scholastic benefits such as interaction with real-world scientific investigations and scientists, computer simulations, and opportunities for greater student motivation.

Web-based activities expand research opportunities by allowing students to interact with real scientific studies, e.g., citizen science projects such as the Audubon Society's Christmas Bird Count; Monarch Watch; Extension Volunteer [Water] Monitoring Project; and Project Budburst. These activities are designed to engage students directly with authentic scientific research, materials and natural phenomena via virtual resources and technologies such as online data collection and databases, and web-mediated presentation media.

Simulations allow meaningful representations of inquiry experiences not possible with real materials due to safety concerns, insufficient time to collect meaningful data, or inadequate laboratory equipment, materials and supplies. For instance, virtual frog dissections allow students too squeamish or with ethical conflicts to participate in this biology lab, while manipulations of virtual environmental conditions allow students to study fluctuating predator/prey relationships in an ecology lab. Moreover, without set-up and tear-down time, students have more instructional minutes for meaningful investigations (Hofstein & Lunetta, 2003).

An additional benefit of computer-mediated instruction is that of student motivation. Having been raised in the digital age, students are particularly comfortable with technology. Adding meaningful technology to the curriculum tends to motivate students; motivation, in turn, leads to increases in learning and greater achievement (Becker, 2000; Hooft, 2005). Students cited greater control of their learning experiences, the ability to proceed at their own pace, and access to additional help online among the top reasons they embrace web-based technology in the classroom (Project Tomorrow, 2009).

<u>Limitations.</u> Teachers' willingness to add online curricula depend upon various factors, including: Perception about the usefulness of technology in the curriculum (Ertmer, Addison, Lane, Ross & Woods, 1999); experience in taking courses or teaching online (Project Tomorrow, 2009); time constraints imposed by high-stakes testing (Butzin, 2004); and issues of access and support (Hew & Brush, 2007). Educators who view technology as an integral component to the curriculum, as well as those who have experienced using the Internet in their own college education, through professional development or as an instructor are more likely to incorporate this media. Conversely, those who view technology as unimportant, or irrelevant to the assessed core

curriculum, tend to allow computer usage only after the completion of daily lessons, for remediation activities, or as a reward (Butzin, 2004; Ertmer et al., 1999).

As with general science instruction and hands-on activities, the time required for identifying and choosing objectives-aligned software (Butzin, 2001) or researching and preparing web-mediated lesson plans (Hew & Brush, 2007) presents a significant barrier to the incorporation of technology in elementary science curricula. The inability of overwhelmed computer specialists to provide prompt technological support for computers in the classroom (Cuban et al., 2001), as well as competition among teachers for access to central school computer labs (Hew & Brush, 2007) further hinder efforts to meaningfully utilize technology.

Finally, the NSTA expressed concern about the appropriate application of technology: "While reading about science, using computer simulations, and observing teacher demonstrations may be valuable, they are not a substitute for laboratory investigations by students" (NSTA, 2007).

<u>Blended Learning</u>

For many educators, blended learning is an advantageous compromise between hands-on and online learning:

> …teachers can create instructional activities and assignments that give students the opportunity to work collaboratively, tapping their interest and abilities in social learning. In addition, project-based and experiential learning can also be facilitated through blended models, giving students the opportunity to conduct research online, participate in group work, and then develop multimedia projects that showcase their learning processes and outcomes. (Blackboard, 2009, p. 4)

<u>Definitions.</u> At its most basic level, blended learning, in which multiple modalities are employed to best teach a given lesson plan, is an everyday occurrence in

the classroom. As a more formal pedagogical method, blended learning has been defined as a teaching strategy that combines online and traditional face-to-face instruction (Allen, 2008, Blackboard, 2009) to take advantage of the best features of both strategies (Alvares, 2005; Watson, 2008). For the purpose of this project, blended learning is defined thus: "Blended learning should be viewed as a pedagogical approach that combines the effectiveness and socialization opportunities of the classroom with the technologically enhanced active learning possibilities of the online environment…" (Dziuban, Hartman & Moskal, 2004, p. 3).

Benefits. A blended approach has a major benefit for teachers: Time. While the development of both web-based and laboratory activities require an initial time commitment longer than that necessary for the development of either modality individually, the investment returns great gains. Once implemented, the combination of modalities allows teachers more time to interact with individual students, differentiating and individualizing instruction across the group of learners (Watson, 2008).
The NRC also recommends a blended approach in the larger curriculum: "Computer-based representations and simulations of natural phenomena and large scientific databases are more likely to be effective if they are integrated into a thoughtful sequence of classroom science instruction that also includes laboratory experiences" (NRC, 2005, p.75).

Benefits and Limitations: Incomplete research. There are many publications and presentations touting the benefits of blended learning for a variety of educational uses, including: Enriched and personalized learning experiences, learning expanded beyond the school day, and time for materials preparation (Watson, 2008);

dropout-recovery and credit-recovery (Mackey, 2010); and differentiated learning strategies and increase in learner capacity without commensurate increase in budget or staff (Blackboard, 2009).

Furthermore, successful programs implemented in several school districts from around the country have been highlighted in professional publications (Watson, 2008), and webcasts (see for example Patrick & Patel, 2010). There are case studies underway in several districts around the nation, including: Cincinnati Public Schools (OH); Odyssey Charter Schools (NV); Commonwealth Connections Academy, (PA); Chicago Virtual Charter School (IL); Hoosier Academy (IN); Kentucky Virtual School (KY); VOISE Academy (IL); Community High School (MI); and Omaha Public Schools (NE; Patrick & Patel, 2010).

There are three concerns with this proffered evidence. First, while the case studies may appear promising, they have not been published and subject to peer-review. Therefore, data presented must be considered preliminary.

Second, while the presentations and webcasts were hosted by educational organizations, one of the hosting organizations, International Association for K-12 Online Learning, is a predominant proponent of online education. This is not necessarily a problem; however, political interests must be taken into consideration when evaluating data presented.

Third, a random review of several presentations and webcasts revealed that many were sponsored by Blackboard Inc., a publicly held software developer for new products targeted to meet the purported needs of a new generation of learners. Again, this is not necessarily problematic: Corporations often sponsor events such as athletics in exchange for publicity. However, as with all areas of scientific research, whenever "industry" funds research or the presentation thereof, proffered evidence should be evaluated with this relationship in mind.

Blended Unit, Elementary Science and the One-Room Schoolhouse

In addition to the literature discussed above, a separate search was conducted in an endeavor to uncover contemporary research similar to the current project. The terms "blended unit," "one-room schoolhouse," and "elementary science" and combinations thereof were used. Search engines included Google Scholar and the following CSU, Chico Meriam Library databases: Academic Search Premier, ERIC, Library, PsycINFO, and SocINDEX with Full Text. Limiters included scholarly (peer reviewed) journals, full text articles, and the time period 1990-2010.

Using these parameters, three studies of moderate relevance to the current project were found. Matson, DeLoach, and Pauly (2004) produced and tested a series of learning activities to promote interest in science and math in rural and underserved schools. The Robot Roadshow, a mobile robot laboratory, engaged K-6 students in extended activities, including pre-visit grade-specific workbooks and visit-day multi-modal activities such as a mini-lecture, NASA video, demonstration, and student-centered inquiry lessons. The agenda was identical for all K-6 students.

The researchers tracked participants for an initial three-month period; a multi-year longitudinal study to determine student content knowledge retention has not yet been published. Over 1,200 students were served the first year and 2,000 the second year.

Focus on Butterflies

McPherson (2009) described a multi-location, web-based collaborative curricular project titled, “A Dance with the Butterflies” for Pre-K through fourth grade students. Like the current project, the McPherson unit used butterflies to provide a cohesive thread for a variety of online and classroom learning activities. In contrast, the McPherson project applied brain-based neural network research from the Center for Applied Special Technologies and utilized principles of Universal Design for Learning in the instructional design. Teachers received specialized training and were then provided online curricular support, including a blog to share information. Some teachers used a blended approach and integrated butterfly habitat construction and other hands-on activities with the online component. A multiple measures strategy was used to gauge student achievement, ranging from pre/post and multiple choice tests to concept maps, drawings, poetry, skits, and additional works of art. The author concluded that these assessment measures and student engagement deemed the unit a success. While a few samples of student work were provided, greater details about the number of teacher and student participants, measures used, challenges and failures, and so on, were not provided in the report. The only demographic data supplied was the location of the teachers and grades taught.

While the project contained similarities to this researcher’s (e.g., use of butterflies as a unit focus; blended approach, online teacher support and curriculum ideas) the McPherson project was designed to test a discrete type of pedagogical theoretical approach and principles on student learning; material resources and educator support seem to have been a necessary secondary component. Conversely, the current project was designed to provide and test the effectiveness of a blended curriculum unit without the benefits of substantial material resources, educator training and other direct support.

Becoming WISE

Williams, Linn, Ammon, and Gearhart (2004) conducted a two-year case study of a novice, urban fifth grade teacher introducing a WISE learning unit into her curriculum. The educator had been teaching for 2.5 years and had "limited experience with technology, inquiry, and science" (Williams, 2004, Teacher section). The researchers conducted multiple interviews and observations and collected reflective writing to identify change in her use of inquiry in science. Results showed that over time the teacher's classroom practices shifted from more logistics-oriented to more inquiry-oriented. The researchers contended that increased pedagogical content knowledge from having repeated opportunities to teach the WISE unit, and support from the curriculum and other professionals to reflect on her teaching practices, led to this shift.

The study is similar to the current project in two primary ways: the research conducted was teacher-centered, and it incorporated online inquiry, including a WISE unit. The differences in the studies revolve around the blended nature of the current research: in this project, the WISE unit was just one component of a blended learning unit rather than the sole focus of the intervention.

Finally, wider searches using the single terms "one-room schoolhouse," "blended unit," and "elementary science" were conducted to determine if additional relevant literature could be located. Source material relevant to this project was identified and discussed in either the Introduction or a Literature Review section.

Each of the case studies previously listed was based upon a school-wide model and contained course-level material. By contrast, the current project was designed for the classroom and contained unit-level material. Neither scholarly nor anecdotal researches at this level of specificity were found in the studies.

CHAPTER III

METHODS

Case Study

A study was conducted using a case study protocol and data collection triangulation procedures outlined by Yin (2003). A mixed methods design was employed, including: Direct observations and participant-observations; telephone, individual and focus group interviews; and document acquisitions, e.g., surveys, questionnaire, journals, and pre/post content tests.

Participants

Study Site

The study site was located in a faith-based, private elementary school in Northern California. The teacher and all students in the school were invited to participate in the study. All parents allowed their children to take part, and nine of the ten students enrolled agreed to participate. No incentives were offered for involvement; students completed the proffered coursework and testing as a normal part of their academic routine.

The school building was physically attached to the church, but had a separate entrance and was run as a stand-alone program. The building' s interior arrangement was composed of one classroom, one conference room/teacher's office, a kitchen, an auditorium and two restrooms, all connected by three hallways. Outside of the school a fenced recreation area contained standard playground exercise equipment, a small blacktop area, a small grassy area, and a large undeveloped area.

Inside of the classroom were three computers, a printer, a blackboard, and an overhead projector; an additional computer was available for student use inside the conference room. Initially, students sat at desks in groups of two placed face-to-face; this configuration was later changed to standard rows of desks facing the blackboard.

Demographics

Over the course of the study, student enrollment was fluid. Ten pupils were enrolled during at least part of the eight-week session; six participated in all aspects of the learning unit and case study. Data obtained from these students and the teacher was included in the case study results.

Students came from four families residing in the surrounding and outlying rural communities; commute times to school ranged from 15 to 45 minutes. Student demographics are listed in Table 1.

The teacher, Mrs. D., is credentialed as both an elementary teacher and child development program director, has advanced training in special education, and is currently matriculating an administrative degree. She has been teaching for six years; this was her second year at the participating school. Educator demographic data is listed in Table 2.

Learning Unit

The eight-week blended ecology unit, entitled “Energy through the Ecosystem,” was composed of an interactive series of hands-on and web-based lessons.

Table 1

Student Demographics

# Participants:	6	
Gender:	Male: 3	Female: 3
Ethnicity:	Caucasian: 5	Hispanic: 1
Age:	8-13	
Grade[a]:	2-7 with vertical remediation and advancement in individual subjects	

[a] Learners attended grades two through seven and were advanced or remediated vertically based upon placement tests; informal and formal subject matter assessments; and teacher observation. For example, a child placed in fourth grade for most subjects might study third grade math and fifth grade reading to meet his or her individual learning needs.

The website for this unit was accessed at the following url: http://web.me.com/mwestbie/energy. The website contained the entire unit, including the scope and sequence, background information, laboratory, and online activities (see Appendix A).

Website overview

Similar to a concept map, the home page of the website was designed as a wheel (see Figure 1). *Home* was represented by the center button, while *Monarchs I*, *Photosynthesis*, *Food Webs*, and *Monarchs II* buttons led students to respective learning concepts (see Appendix A). A *Teacher's Corner* link directed the teacher to the

Table 2

Teacher Demographics

Participants:	1
Gender:	Female
Ethnicity:	Caucasian
Age:	52
# Years Teaching Experience:	6
Credentials Held:	Clear Multiple Subject Teaching Child Development Program Director

recommended scope and sequence; subject matter backgrounds; lesson plans and handouts for in-class activities and laboratories; and additional optional activities and resources for each topic. *Teacher's Lounge* and *Researcher's Lounge* buttons led interested parties to information about the teacher and the researcher, respectively.

Learning Concepts Overview

Students explored three life science concepts, including: Photosynthesis, food chains, and food webs (the latter two concepts were consolidated in the *Food Webs* section). Students chose Monarch butterflies as a representative species with which to apply new conceptual knowledge. The learning unit's Scope and Sequence is shown in Appendix A; individual sections are described below.

Monarchs! Students studied Monarch butterflies over the course of the unit. This topic was chosen to provide cohesiveness among the concepts, enhance student

Figure 1. Home page: Energy through the Ecosystem website.

motivation, and provide a conceptual anchor for further exploration of the subjects presented.

Learners were introduced to the idea of *citizen science*: Also known as *public participation in scientific research*, citizen science projects rely on non-scientists to perform or manage research-related tasks such as observations, measurements or computations[2]. For this unit, the citizen science project Monarch Watch was chosen (www.monarchwatch.org).

To create a Monarch Waystation (a habitat created to provide food and shelter for all life stages of the butterfly), students planted fall seeds in August; the class was scheduled to plant spring seeds in March or April. The first Monarch count is expected for Fall 2010. Additional classroom lessons, including the extensive active reading sequence “Gulliver’s Story,” were incorporated throughout the eight-week unit.

The online portion of this topic was divided into two sections to support and reinforce the unit (http://web.me.com/mwestbie/energy). In *Monarchs! Part I*, students were introduced to this species of butterfly, and followed links to view short educational videos about its life cycle and habitat. In *Monarchs! Part II*, students applied the concepts learned from other sections to develop a deeper understanding of the roles photosynthesis and food webs will play in the Monarch Waystation.

<u>Photosynthesis.</u> In this section learners explored the causal mechanisms of photosynthesis (how does it work?) and its impact on living systems (why is it important?). Lessons were chosen to challenge and reframe the common perception held by students that heat from the sun, rather than light energy, is a primary component of the photosynthetic process (Berthelsen, 1999).

As students see plants grow, bloom, and set fruit in the spring and summer then “die” in the winter, they often come to a very commonsense conclusion that the

[2] The annual Christmas Bird Count, sponsored by the Audubon Society since 1900, is the longest-running citizen science project.

warmth of the sun makes plants grow (Berthelsen, 1999). To test the effects of heat and light energy on photosynthesis and encourage students to reframe their perceptions, pupils completed a three-week, multi-stage classroom experiment in which they masked leaves with construction paper and observed changes in photosynthetic activity as compared to control plants. The lesson plan was adapted from "Is Light Necessary for Photosynthesis? (www.misterteacher.com/nature/fallleafchange.html); teacher and student materials for this laboratory are included in Appendix A. A short culminating activity, in which the class viewed an online video segment and discussed differences in growth between plants grown in dark and light conditions, was included to reinforce the idea that sunlight is necessary for photosynthesis.

Online photosynthesis lessons provided the majority of the direct instructional content for this section. Student activities included: Pre and post content tests, the "Photosynthesis Song," vocabulary research, interactive educational videos, and a culminating classroom poster project to support new content knowledge.

<u>Food webs.</u> In this portion of the unit pupils were guided from having a basic conceptual understanding of individual food chains to acquiring an appreciation of the more complex interaction of food chains known as food webs. Learners were also introduced to energy pyramids and trophic levels.

Classroom and web-mediated materials were selected to assist students reframe the common belief that a change (increase or decrease) in the numbers of one type of organism will only affect other organisms in the immediate food chain rather than the larger food web (Griffiths & Grant, 1985). When examining interactions in a food web, students often do not recognize that there are indirect effects on other organisms, or that organisms “far away” in the web will also be affected by the local change (Griffiths & Grant, 1985).

The whole-class activity “Food Chain Game” from the WISE unit *Rainforest Interactions* (http://wise.berkeley.edu) was selected to challenge this perception; the game is easily modifiable to explore student perceptions of the way food webs work.

Classroom activities were designed to introduce and provide a visual overview of biotic energy flow. Students were given subject matter handouts and viewed a variety of overhead illustrations representing land and marine food chains; food web; and energy pyramids. The source materials for these handouts and illustrations were selected from materials available at a variety of online sources, including: Science.org (www.science.org), Virtual Teacher Aide (www.vtaide.com), and the Marine Education Society of Australasia (www.Mesa.edu.au). Pupils participated in a mini-lesson and class discussion regarding the flow of energy between organisms and through trophic levels. A coloring diagram, “Food Chain Checkers” (www.windows.ucar.edu) and the “Food Chain Game (http://wise.berkeley.edu) provided learners with additional content interactions.

Students conducted an eight-week laboratory lesson centered upon decomposition columns (www.bottlebiology.org) that students built and monitored. This activity, conducted over the entire course of the unit, was designed to allow learners to follow the flow of energy to the end of the life cycle, and to show that even “dead” flora support organisms such as fungi and bacteria.

Online lessons, including an interactive quiz and vocabulary research further prepared students to apply their new knowledge to a novel environment (http://web.me.com/mwestbie/energy). The major interactive assignment, *Rain Forest Interactions*, was modified from a vetted WISE project (http://wise.berkeley.edu). Student activities included: The creation of an online food web using a causal mapping tool; prediction of the relative numbers of organisms at each trophic level necessary to sustain the ecosystem; food chain simulations; online research about food webs; the selection and research of an endangered Costa Rican animal and the creation of a food web for that animal; and an online presentation page for the wider sharing of information among classmates. Students were also provided with optional, self-directed activities related to rain forest conservation.

Data Collection

Several data collection methods were employed in the study, including: Direct observations and participant-observations; telephone, individual and focus group interviews; and document acquisitions, e.g., surveys, questionnaire, journals, and pre/post content tests. Each procedure is described below.

Observations

Both direct and participant-observations were conducted during the first five weeks of the unit. During direct observations, the researcher sat at a corner table in the classroom and monitored teacher and student activity. These observations occurred primarily at the beginning of science class when concepts were introduced or reviewed and served as a measure of educator, as well as learner, conceptual understanding. Participant-observations took place during the actual lessons; in this capacity, the researcher assisted students with the online component of the lesson while the teacher facilitated classroom activities. The researcher also acted as an "additional set of hands" to help students set up Monarch seedbeds and create decomposition columns. Field notes were recorded during or after both types of observations.

It is important to note that during these sessions the classroom teacher maintained control of the curriculum and daily lessons, and fielded content-related student questions. The researcher's role was defined as a teacher's aide or classroom volunteer. Subject matter questions and curricular adjustments were discussed outside the presence of the students to ensure that the material was taught with "one voice" and that the students did not transfer the role of educator to the researcher. This was crucial, as students knew they were "testing" a new learning unit for the researcher; there was a concern that learners would see the researcher, rather than their teacher, as the "expert" in this area of learning. Therefore, great pains were taken to ensure that their teacher was seen as the sole educator.

Interviews

In addition to informal conversations with the teacher and students over the course of the unit, the researcher conducted several individual telephone and in-person interviews with the teacher, and a post-unit focus group interview with three sets of students.

Teacher interviews. For three months prior to the beginning of the learning unit the researcher and teacher engaged in a series of informal telephone and in-person interviews regarding the needs of the educator and the design of the unit to meet those needs. During implementation of the learning unit, informal conversations and after-school debriefings occurred each day the researcher was on site. Finally, an open-ended, focused interview guided by a set of pre-determined questions took place eight weeks after the conclusion of the unit. The time lapse between the end of the learning unit and the final interview was necessitated by the researcher's decision to perform initial analyses from the pretests and posttests and surveys, as well as the school's Thanksgiving break and student Christmas program.

Student interviews. Informal conversations were held with students during science lessons. In addition, a focus group interview, guided by a set of pre-determined questions was conducted on the same day as the teacher's formal interview. Three sets of students of similar age and grade level participated in the focus group interviews.

Document Acquisitions

Participants filled out a variety of documents during the case study. Documents collected are listed in Table 3 and described below.

Table 3

Case Study Participant Documentation

Participant(s)	Document	When Completed
Teacher	Perceptions Survey (STEBI)	Pre- and post-unit
	Evaluation of Materials	Post-unit
	Reflective Journal	Sampled throughout unit
Students	Science Content Test	Pre- and post-unit
	Reflective Journal	Sampled throughout unit

Teacher perceptions survey. Mrs. D completed a Teacher Perceptions Survey (downloaded from Anonymous 2, n.d.) preceding and following instruction of the unit. This instrument is identical to the Science Teacher Efficacy Belief Instrument (STEBI-A; Riggs & Enochs, 1990) except that the name of the instrument as it appears to the teacher on the paper was changed.

The STEBI is a widely used survey instrument (Liu, Jack, & Chiu, 2006) designed to measure elementary teachers' confidence about teaching science, and expectations about how their teaching affects student learning (Riggs & Enochs, 1990). The instrument was designed to measure two scales:

1. In-service teachers' personal science teaching efficacy beliefs (PSTE); and
2. in-service teachers' science teaching outcome expectancies (PTOE)

in a specific (elementary school) context (Riggs & Enochs, 1990).

The STEBI instruments resulted from Bandura's (1977) self-efficacy theory, which proposed that "people are motivated to perform an action if they believe the action will have a favorable result (outcome expectation), and they are confident that they can perform the action successfully (self-efficacy expectation)" (Bleicher, 2004, page 2).

For this study, the STEBI-A was used to measure changes in Mrs. D.'s PSTE and/or PTOE scores pre- and post-unit implementation, which would reflect changes in her levels of confidence and outcome expectancy. The results were measured against the STEBI-B (Bleicher, 2004). Both instruments are described below.

The STEBI-A consists of 25 items in a 5-point Likert scale format with response categories of *strongly agree, agree, uncertain, disagree,* and *strongly disagree*. Negatively worded items are reversed scored, i.e., *disagree* becomes *agree* (Riggs &

Enochs, 1990). Higher scores on the PSTE scale reflect greater confidence in the ability to effectively teach science, while high scores on the PTOE scale indicate a greater expectancy that teaching effectively will result in better learning outcomes (Riggs & Enochs, 1990).

The STEBI-A and STEBI-B are equivalent forms of the STEBI test developed by Riggs and Enochs: the STEBI-A is used with in-service elementary teachers and the STEBI-B with pre-service teachers. The tests are identical with the exception that the STEBI-B reflects future tense (Liu et al., 2006). Enoch and Riggs reported the STEBI-A to be a valid and reliable instrument with reliability coefficients of 0.81 for the PSTE and 0.74 for the PTOE (Enoch & Riggs, 1990). Bleicher confirmed that the reliability of the STEBI-B is essentially the same as STEBI-A with coefficients of 0.87 for the PSTE and .72 for the PTOE (Bleicher, 2004).

Teacher evaluation of materials. The teacher filled out an unmodified copy of a 22-question survey (Capital University, n.d.) to assess the general content, content validity, and level of audience engagement of the materials provided in the learning unit. Though this instrument has not been formally evaluated for reliability and validity, it was selected because it was provided by the Online Evaluation Research Library as an example of a sound evaluation instrument from past, federally-funded curriculum projects.

Science content test. Learners took a pre/post content knowledge test, consisting of 16 multiple choice and one of two alternate short-answer items to measure student learning (see Appendix B). Questions were selected from standardized science tests published by the California Department of Education (2009; three questions) and the

Massachusetts Department of Elementary & Secondary Education (2008; two questions), as well as from quizzes distributed by The Queensland Science Teachers Network (n.d.; seven questions). Four multiple choice and two short-answer questions were designed by the researcher to address pertinent information from lessons in the curriculum for which suitable existing questions could not be found.

Reflective journals. The educator and students periodically reflected upon the unit through short journal entries; participants responded to researcher-designed prompts created to elicit immediate feedback (see Appendix B). Student prompts focused on perceptions about what was learned and attitudes about a given lesson. Teacher prompts asked about strengths and weaknesses of the lesson taught and student engagement with the material. Participants were asked to complete one journal entry for each science lesson.

Analysis

Qualitative data analysis has been described as an ongoing process conducted concurrently with data collection, interpretation and recording based upon the researcher's persistent interaction with and reflection about the data (Creswell, 2009; Savenye & Robinson, 2004). The analytical process proceeds from specific raw data, e.g. transcripts and field notes, through a series of steps in which multiple techniques are employed to lead to more general findings (Creswell, 2009).

For the case study, data collected from multiple sources was organized categorically and chronologically. Analysis methods included data reduction and sorting data (Savenye & Robinson, 2004); simple pattern matching and rival explanations (Yin, 2003).

Data reduction was conducted throughout the study. The researcher looked for patterns, links and relationships among pieces of incoming data and used this information to make new observations and test working hypotheses. For instance, an observation, a casual conversation, and a student journal entry related to a student's frustration with a particular lesson resulted in steps taken to determine whether the disruptive behavior observed and subsequent explanation given (the instructions were not clear so he became frustrated) were in fact related. After ensuring that future instructions were very clear and observing the student at the computer, it became apparent that he skimmed directions, thereby missing important information; that accounted for his frustration.

Data was categorized based upon the four research questions related to teacher confidence, teacher perception, future decisions, and unit efficacy. From these broad groupings, subcategories of descriptions and themes emerged: For instance, researcher field notes and the teacher's reflective journal entries provided descriptions of classroom activities and interactions over time. Themes such as *positive* and *negative* clustered data received from the observations, interviews, and documents into manageable pieces that presented multiple perspectives.

Simple pattern matching of the qualitative data was utilized because known dependent variables were limited to those contained in the research and null hypotheses. This type of data analysis was chosen because much of the data could be sharply delineated into two discrete *yes/ no*, *positive/negative* categories.

Rival explanations were considered throughout the case study as a part of the researcher's reflection process, and were further scrutinized during data analysis. For example, if students failed to learn a concept as thoroughly as desired, then a wide range of possible explanations were considered (such as behavioral disruptions, computer malfunction, problems with the measurement instrument, pedagogical decisions made by the teacher, or problems with the curriculum unit itself), and the data was re-evaluated and re-organized to consider each of these possibilities.

Validity

Three validity strategies, including prolonged engagement, persistent observation, and triangulation were employed to check the accuracy of the case study (Savenye & Robinson, 2004). The first two validity strategies require that the researcher spend a sufficient amount of time in the field to appreciate and understand the context of the phenomenon being studied, to establish trust and rapport with the participants (Cohen & Crabtree, 2006), and to focus on details of the phenomenon that are most relevant, and recognize those that are not (Lincoln & Guba, 1985). Thus, over the course of several prolonged and intensive classroom visits from August 2009 to December 2009, the researcher interacted with participants, established trust and rapport, and eventually became "just another classroom helper." The time spent with the participants allowed the researcher to gain both a global view of the context and culture of the school in which the study took place, and specific details within the environment that were pertinent to the research questions.

Triangulation was described by Creswell as examining evidence from different data sources and using it to build a coherent rationale for themes (2009).

Sources of evidence for this study included observations, interviews, journals, and testing and survey instruments.

CHAPTER IV

RESULTS

Research Question #1

What effects will using a blended science unit have on the teacher's confidence about teaching science content? The data collected pertaining to this question was mixed.

Teacher Perceptions Survey

The teacher completed pre- and post-unit Teacher Perceptions Surveys (aka STEBI-A; Riggs & Enochs, 1990). This 25-item Likert-scale survey measured Mrs. D's confidence along two dimensions: Personal Science Teaching Efficacy (the teacher's confidence in her ability to teach science content) and Science Teaching Outcome Expectancy (the teacher's expectation of producing the desired teaching outcomes). A pre/post comparison revealed a 7% increase in the Personal Science Teaching Efficacy Belief scale, and a 13% decrease in the Science Teaching Outcome Expectancy scale.

Efficacy belief scale. Out of a total possible score of 65, Mrs. D. initially scored a 50.5 and finally scored a 54. Of 13 statements presented in the Teacher Perceptions Survey, responses on the post-survey reflected an increase in the teacher's efficacy belief in six statements; a decrease in three statements; and no change in four statements. A comparison of pre-unit and post-unit survey results is shown in Table 4.

Table 4

Pre-Unit and Post-Unit Responses on the Personal Science Teaching Efficacy Belief scale.

#	Personal Science Teaching Belief Questions	Pre	Post
2	I am continually finding better ways to teach science.	A	SA
3	Even when I try very hard, I do not teach science as well as I do most subjects.	A	U
5	I know the steps necessary to teach science concepts effectively.	U	SA
6	I am not very effective in monitoring science experiments.	D	A
8	I generally teach science ineffectively.	D	D
12	I understand science concepts well enough to be effective in teaching elementary science.	A	SA
17	I find it difficult to explain to students why science experiments work.	D	D
18	I am typically able to answer students' science questions.	A	SA
19	I wonder if I have the necessary skills to teach science.	D	U
21	Given a choice, I would not invite the principal to evaluate my science teaching.	SD	D
22	When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.	D	D
23	When teaching science, I usually welcome student questions.	SA	SA
24	I do not know what to do to turn science on to science.	D/U	SD

Note. SD=strongly disagree; D=disagree; U=uncertain; A=agree; SA=strongly agree.

On multiple occasions during casual conversation, and again during the final interview, Mrs. D. commented that she was increasingly comfortable teaching science and using online content: "…as far as science, I have appreciated your help this year, because I feel more confident after working with you." She further noted, "using the online [curriculum] that you already have set up was very helpful to me" (Interview, 12-9-09). This suggests that the personal support and good curriculum helped to raise Mrs. D.'s confidence level. In survey item #5, "I know the steps necessary to teach science concepts effectively," the teacher's pre-and post-survey responses (a change from *undecided* to *strongly agree*) reflected a positive change in personal efficacy belief; the increase in the scored response rose significantly compared to the average scored response of Bleicher's teachers (see Table 5). The scored response on Mrs. D's post-survey rose slightly above three standard deviations from the mean, a strong indicator of the positive change in her personal efficacy belief. Mrs. D annotated her response to several questions on the post-survey which helps provide a context and explanation for the Likert scale ratings. For example, to item #5, she noted, "This unit outlined the concepts well." This suggested that the scaffolding of the individual topics, and the sequential design leading from one interrelated topic to another in the blended unit gave Mrs. D. a model by which to teach the science content. Having a "blueprint" to follow and the experience of having taught the material would have created conditions favorable for the sharp increase in confidence level.

This possibility, that the unit provided Mrs. D with a model for good science teaching practices, is supported by item #24, "I do not know what to do to turn students on to science," for which Mrs. D's response changed from *disagree/undecided*, which

Table 5

Changes in Pre-Unit and Post-Unit Scored Responses on the Personal Science Teaching Efficacy Belief Scale Compared to Results of Bleicher's 2004 Survey of 290 Preservice Elementary Teachers

Item #	Pre-survey score	Post-survey score	Bleicher mean± SD (2004)	Change compared to Bleicher
2	4	5	4.48 ± 0.57	
3	2	3	3.78± 0.98	Increased to the mean
5	3	5	2.33± 0.86	Increased above the mean
6	4	2	3.82± 0.81	Decreased below the mean
8	4	4	4.14±0.74	
12	4	5	2.88± 0.96	Started above and increased further above the mean
17	4	4	2.87± 0.84	Above the mean
18	4	5	3.47± 0.84	Increased above the mean
19	4	3	3.78± 1.06	
21	5	4	3.47± 0.96	Decreased to mean
22	4	4	3.78± 0.84	
23	5	5	4.37±0.7	
24	3.5	5	3.26±1.01	Increased above the mean

approximated the mean of Bleicher's teachers, to *strongly disagree*, which exceeded Bleicher's mean by 1.5 standard deviations. A few additional comments were made in response to items pertaining to the learning unit, "This unit boosted my use of Internet and other resources" (item #2) and lesson plans, "With good lesson plans and video [explaining why science experiments work] is not a problem (item #17). These give further support to the notion that Mrs. D found that the unit served as an important model and thus helped her gain confidence in her science teaching efficacy.

Of the three statements in which the score decreased, only one item appeared to actually reflect a lowered personal belief in the ability to teach science. Item #6, "I am not very effective at monitoring science experiments," started as *disagree* and changed to *agree*. When compared to the teachers in the Bleicher survey, the scored response fell over two standard deviations from the mean. Mrs. D. added the following comment to this item: "I was better in the single grade classroom; however, we are still watching the decomposition columns." Unfortunately, her response does not resolve the question as to whether this unit might have made her feel less able to monitor science experiments than previously or whether she was simply not able to respond at that time since some of the science experiments that were part of the unit such as the decomposition columns and Monarch habitat construction were still ongoing. Item #26, "Given a choice, I would not invite the principal to evaluate my science teaching," recorded a change from *strongly disagree* to *disagree*. The change appears to hold no particular relevance, as Mrs. D. was the principal/teacher; furthermore, in her comments, she noted that she would invite her [district] supervisor to observe her teaching. Item #19, "I wonder if I have the necessary skills to teach science," changed from *disagree* to *uncertain*, yet these results were mitigated by Mrs. D's comment "I know I can teach with good lesson plans."

Additional evidence. In addition to the Teacher Perceptions Survey, additional data indicated that the teacher's belief in her ability to teach science effectively had increased. The researcher's note of April 2, 2009 recorded the following comment: "She loves science but doesn't feel terribly confident teaching it." The note continued with the comment that she was particularly uncomfortable teaching how ecosystems and food webs fit together (Research journal, 4-2-09). After completing the unit, Mrs. D. expressed, "I feel more confident after working with you" (Interview, 12-9-09).

Another statement was more guarded. When asked whether she was comfortable looking at curricula and deciding whether or not the content was valid, invalid, or would lead to scientific misconceptions, the educator replied: "Sometimes I feel really comfortable with that, sometimes I don't...science is not my first background" (Interview, 12-9-09). This was still an improvement over her comment several months earlier, wherein she had expressed the more generalized concern quoted above. Finally, during researcher visits there was a general sense of "smoothing out," that over time the teacher was increasingly confident teaching the science content.

Outcome expectancy scale. As previously noted, there was a 13% decrease in the teacher's perception that her teaching would have desired outcomes. From an initial maximum score of 60, Mrs. D's pre-unit score of 47 fell to 41. Of twelve statements presented in the survey instrument, responses on the post-survey reflected an increase in the teacher's outcome expectancy in three statements; a decrease in five statements; and no change in four statements. A comparison of pre-unit and post-unit survey results is shown in Table 6. Mrs. D.'s scores are compared to the average scored response of Bleicher's teachers in Table 7.

The three statements in which the score increased seemed to reflect the teacher's general sense of responsibility for student achievement. For instance, to item #14, "The teacher is generally responsible for the achievement of students in science," for which her rating changed from *agree* to *strongly agree,* the respondent noted, "As in all subjects, the buck stops here!" The scored response on the post-survey approximated 1.5 standard deviations above the average responses in the Bleicher study, an indication that Mrs. D's sense of responsibility not only increased over the course of the unit but was higher than that experienced by other elementary teachers. The fact that Mrs. D. was also the principal of the school may have enhanced the feeling of responsibility for student learning. There was also a strong change in response to item #7, "If students are underachieving in science, it is most likely due to ineffective science teaching," from *undecided* to *strongly agree*. However, the annotation "Some students struggle across the grades; what I look for then [is] to improve always" suggested that she considered educators responsible to consider the needs of a struggling student, rather than asserting that the science teaching itself was necessarily ineffective.

This point was reinforced in notation following item #20, "Effectiveness and science teaching has little influence on the achievement of students with low motivation: The challenge is to find what their motivation triggers are." Remarks accompanying the five survey statements that decreased in score signified a shift in perception from a pre-unit stance in which the teacher appeared to take on the majority of the responsibility for student learning, toward a post-unit stand that held students more accountable for

Table 6

Pre-Unit and Post-Unit Responses on the Personal Science Teaching Outcome Expectancy scale.

#	Outcome Expectancy Question	Pre	Post
1	When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	A	D
4	When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	A	A
7	If students are underachieving in science, it is most likely due to ineffective science teaching.	U	SA
9	The inadequacy of a student's science background can be overcome by good teaching.	SA	A
10	The low science achievement scores of some students cannot generally be blamed on their teachers.	A	A
11	What a low achieving child progresses in science, it is usually due to extra attention given by the teacher.	SA	A
13	Increased effort in science teaching produces little change in some students' science achievement.	D	A
14	The teacher is generally responsible for the achievement of students in science.	A	SA
15	Students' achievement in science is directly related to their teachers effectiveness in science teaching.	U	U
16	If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	A	A
20	Effectiveness in science teaching has little influence on the achievement of students with low motivation.	D	D/SD
25	Even teachers with good science teaching abilities cannot help some kids to learn science.	SD	A/SA

Note. SD=strongly disagree; D=Disagree; U=uncertain; A=agree; SA=strongly agree.

their own learning and recognized the influence of factors beyond the teacher's control in determining a student's learning. For example, there was a substantial change in response (from *strongly disagree* to *strongly agree/agree*) to item # 25: "Even teachers with good science teaching abilities cannot help some students to learn science." The teacher noted, "There are students who will not learn because of other issues, but effective teaching can mitigate many challenges." Two other comments confirmed the shift in perception. Mrs. D. changed her response to item #9, "The inadequacy of a students science background can be overcome by good teaching," from *strongly agree* to *agree*. With respect to this shift, the teacher noted, "To a certain degree. It takes time, energy and effort, but [it] can if the student is willing."

The reduction in her response to this item brought her beliefs more in line with that of the average teacher in the Bleicher study. Similarly, a comment in response to item #13, "Increased effort in science teaching produces little change in some students science achievement," read, "*Some* being the operative word; there are students it is very challenging to excite [emphasis in original statement]." In each of the above statements, the teacher did not absolve educators from responsibility for student learning, but rather seemed to acknowledge that educators could not control all factors that might influence student learning. Through these responses, Mrs. D. tempered her item #14 conviction; although the teacher is primarily responsible for student learning, student cooperation and prior scientific background are major contributing factors in learning. She seemed to believe that it is difficult to improve the performance of some students, no matter how good the teaching may be.

Table 7

Changes in Pre-Unit and Post-Unit Responses on the Science Teaching Outcome Expectancy Scale to Compared to Results of Bleicher's 2004 Survey of 290 Preservice Elementary Teachers

Item #	Pre-survey score	Post-survey score	Bleicher mean± standard deviation (2004)	Change compared to Bleicher
1	4	2	3.77± 0.97	Decreased below mean
4	4	4	4.16± 0.7	
7	3	5	3.31± 1.01	Increased
9	5	4	3.68± 0.74	Decreased to average
10	2	2	2.76± 0.92	
11	5	4	3.68± 0.85	Decreased to average
13	4	2	3.43± 0.99	Decreased below average
14	4	5	3.71± 0.84	Increased
15	3	3	3.49± 0.91	
16	4	4	3.39± 0.84	

Note. Items #20 and #25 were removed from the Bleicher (2004) study and are therefore excluded from the table.

<u>Additional evidence.</u> Observations and reflective journal entries supported the results of the Science Teaching Outcome Expectancy scale. At the beginning of the case

study students were settling into the new school year; learners got along well with each other and were very cooperative with the teacher. During casual conversation, Mrs. D. mentioned that the first two weeks had been a wonderful start to the school year and she was very excited by the positive student behaviors and interactions. Within another week, however, classroom dynamics became more chaotic. During one lesson, it was noted that two children (out of eight) were distracted, argumentative and disruptive to the lesson in progress (Research journal, 8-27-09). These two students had diagnosed behavioral disorders. Unfortunately, two other students were particularly impacted: One pupil had a learning disability, and became frustrated when the classroom was boisterous because it interfered with the already difficult processing of new material: “I didn't like when another person was disturbing my partner and my work” (Student reflective journal, n.d.). The other student was academically gifted, but lacked social skills and also became easily frustrated. The two pupils with behavioral disorders were able to maintain a modicum of self-restraint for short periods; however, several instances were observed in which the teacher had to intervene and remove one of the students for a cooling-off period.

Two weeks later, the following notation was made: “[Mrs. D. is] very good with students, so respectful. I think this may be a transition time, in which ‘the honeymoon is over’ but a new paradigm is developing” (Research journal, 9-10-09). This sense of “settling in” is common to classrooms at the beginning of the school year.

While classroom factors appeared to play a large role in the decline in the outcome expectancy score, the analysis was unable to uncover any data pertinent to the question of whether the blended curriculum unit or the teaching of it was a factor in the decline. There were no statements or other documentation that served to either include or exclude the learning unit. It remained unclear, then as to whether additional factors besides classroom dynamics contributed to the reduction of the Science Teaching Outcome Expectancy score.

Because the Personal Science Teaching Efficacy Belief scale increased while the Science Teaching Outcome Expectancy scale decreased, the teacher perceptions survey yielded mixed results. Originally, it was hypothesized that Mrs. D. would be more confident because she had access to a carefully-designed, packaged curriculum. This hypothesis was unsupported. At no time did the teacher utilize the unit as proffered in packaged form. Rather, Mrs. D. modified instruction throughout the length of the unit (Research journal, 9-10-09; Interview, 12-9-09). She explained the habitual strategy:

> Where I work, the curriculum I was to use was fairly old. That's why I do a lot of augmentation [to update the material]. And why I use standards to find other things, to create my own and do what I think shows kids a broad view of science and what was studied before… I enjoyed using what you have designed…[e]ven though I pulled a lot of other things in, that is just my style…I don't do a curriculum package. I take from the curriculum, and I take from my curriculum guides of what I have to teach, and I often create a lot of my own. I borrow from people who have done some pretty cool curriculum...like yours. And that's how I do it.... I tend to use those [websites] that I found that have something there of substance, I will bookmark them and keep them in the back of my mind. (Interview, 12-9-09)

The teacher described additional steps taken to meet the needs of a faith-based curriculum: “Because we're creationists, I am very careful about the content…. a lot of work we do, I have to do a lot of filtering” (Interview, 12-9-09). Mrs. D. replaced the action reading selection Gulliver’s story, a secular tale supplied in the instructional sequence, with Monica Monarch, another story that was biblically based (Teacher reflective journal, 9-3-09). She added that she would extend this portion of the unit further in the future: “next time [I would] have the students write their own butterfly or other food chain story to cement the concept of lifecycles and interrelations” (Teacher evaluation of materials, 11-2-09).

The question as to whether the blended science unit had an effect on the teacher's confidence in teaching science content was not clearly answered. There were substantial gains in some of the Personal Science Teaching Efficacy Belief areas but losses in Science Teaching Outcome Expectancy. The specific hypothesis that the teacher would benefit from a packaged curriculum was refuted.

Research Question #2

What effects will using a blended science unit have on the teacher’s perceptions about teaching science? It was hypothesized that Mrs. D. would benefit from a blended unit because it offered her flexibility to address immediate classroom logistical problems. However, results are mixed regarding whether the experience with hands-on and online teaching styles through the blended unit changed the teacher’s perceptions about teaching science.

Flexibility

The learning unit allowed the educator to teach the content as packaged, or to make modifications to meet changing learning and instructional needs. The following examples illustrate instances of modification by the instructor that were supported by the flexible design of the learning unit:

- Students would ordinarily have explored the first photosynthesis webpage then selected either multiple short segments of an online photosynthesis video or the single long segment to view. Mrs. D. directed students to skip introductory material and watch the long version to meet a limited class time requirement. Learners completed the entire online photosynthesis section on subsequent science days (Observation, 9-1-09).

- In response to the failure of two out of four classroom computers at the beginning of science class, hands-on activities were extended, while the online sessions were abbreviated on one day (Observation, 9-8-09). When computer problems persisted, students were divided into three groups and rotated through three learning stations (two hands-on and one computer station) on another day.

- Pursuant to a science quiz given September 22, 2009, Mrs. D. altered the sequence of instruction and redirected some students to return to photosynthesis, while others were allowed to move on to food webs (Personal communication, 9-24-09).

- Students were observed moving freely between hands-on activities (e.g. the plants and the decomposition columns), and online content during unscripted science time (Observations, 9-15-09, 9-17-09, 9-24-09). Mrs. D. reported that some students returned to the Photosynthesis Song even after the completion of the learning unit (Interview, 12-9-09).

Mrs. D. explained that she routinely adapted instruction to meet the competing learning needs triggered by different ages, different grades, and different learning styles of the students:

> One of the biggest challenges is you have to adapt. If you're going to teach whole class…you have to really adapt from my first grader who was barely reading,… to my seventh graders, two of which are reading off the charts. One of them, I know, has read college textbooks. And not just read them. Understood them…. [T]hen you have so many different learning styles in so many different grades. It's another layer. There [are] just all these layers that you stack up, and you pray every day that you get through them. (Interview, 12-9-09)

She further noted, "... what you gave me was for the middle-of-the-road. And I appreciated that, because we talked about that" (Interview, 12-9-09).

Mrs. D. used the unit to accommodate her youngest learners by reducing the amount of material they were required to cover without "dumbing down" the content. Young learners also completed the online activities; one second grade student surprised Mrs. D. by keeping up with the older students and understanding most of the material presented to her (Interview, 12-9-09).

Perceptions about Teaching Science

Interviews and observations provided evidence that the teacher's perceptions about teaching science had changed to place greater value upon online instruction and hands-on learning than before the unit. However, when faced with persistent behavioral and computer challenges, Mrs. D. set aside all online content in lieu of direct instruction. The online curriculum was the primary mode of interactive learning designed for the food webs content area because students were to apply new knowledge in a comprehensive culminating activity through the WISE website to promote deeper conceptual understanding of energy flow through the ecosystem. Students were allowed to access the online portion of the food web section, most importantly the rainforest food web exploration from WISE, on their own (Interview, 12-9-09).

Online instruction. The teacher's concern that students be technologically literate was clearly evident. Mrs. D. noted that students "liked the computer interaction" (Teacher evaluation of materials 11-2-09). Student access to home computers ranged from limited to non-existent. Children from two families had no access to computers at home; those from two families had limited access. None of the learners had their own computers. Furthermore, Internet access was limited for those students with home computers (Students' interview, 12-9-09). Mrs. D. expressed concern about this: "But the reality is that technology is what they're going to work with in the future. So if they don't learn how to do technology, you're crippling them" (Interview, 12-9-09). It was apparent from the interview that the educator considered computer technology in the classroom to be an important part of the school curriculum and would like to incorporate more technology in the science class.

Mrs. D. pointed out that computer usage addresses multiple learning styles: "Three [tactile, auditory, and visual] are hit when you use a computer. You're moving the mouse, you're hearing it in your ears…and you're seeing it with your eyes. The more modalities that you touch, the more methods you have, the more input forces, the better absorption of the material. That's research-based" (Interview, 12-9-09).

Hands-on instruction. Mrs. D.'s initial reaction to the addition of hands-on science instruction was enthusiastic, as the students planted seeds for the Monarch Garden and began working in multi-age groups (Observation, 8-25-09). She reported that students "liked and related [their] personal experiences with Monarchs," and looked forward to seeing the butterflies in the spring (Teacher reflective journal 9-3-09).

As classroom dynamics changed over the first few weeks of school, however, she noted emerging problems. To the question, "What did not work in this lesson?" she noted "Multi-age grouping and prodding older [students] to work/mentor younger [students]" (Teacher reflective journal, 9-10-09), while the same question a week later elicited the comment, "Boys who could not focus after transitions" (Teacher reflective journal, 9-17-09). Despite these and other behavioral challenges previously discussed, students completed the three-week photosynthesis, and eight-week decomposition columns lessons, suggesting that the teacher was committed to continuing these hands-on activities. The decomposition columns were still being observed into December, six weeks after the end of the unit (Students' interview, 12-9-09), suggesting that they enjoyed participating in the hands-on lab and that Mrs. D responded to their enthusiasm. Mrs. D. planned to continue the Monarch Watch project and add other experiments: “there's going to be more of that coming up this next quarter…” (Interview, 12-9-09).

Mrs. D. also “believe[d] strongly in field trips” (Interview, 12-9-09) as an inexpensive way to incorporate hands-on lessons and increase student engagement, and stated that she routinely included field trips into her science curriculum (no field trips were scheduled during this study). A Red Bluff geology store, the Imaginarium in Grass Valley, and Bidwell Park were chosen to support physical science education, while the Turtle Bay Exploratory Park in Redding, the Bidwell Park nature center in Chico, a nature center in Red Bluff, and frequent interpretive nature walks around the school were selected to add life science experiences (Interview, 12-9-09).

<u>Direct instruction.</u> As previously noted, Mrs. D. used direct instruction to mitigate behavioral and computer problems during the portion of the unit (primarily the food web section) that the researcher was not in the classroom. Those obstacles may not be easily overcome. Two of the students had diagnosed behavioral disorders that resulted in an intermittent classroom disruption; without a second adult in the room to redirect these students, Mrs. D decided to discontinue rotating learning stations. Moreover, computer difficulties continued to plague the classroom throughout the eight weeks of the learning unit; while one of the two computers was repaired, the other remained unable to

access the website. This reduced the available student computers to three, two of which temporarily crashed at least once each and resulted in an inconsistent online availability (Observations, 9-8-09, 9-24-09; Students' interview 12-9-09). Given this difficult situation, the teacher's decision to do whole group, direct instruction in lieu of the online components of the unit was reasonable, though not the only choice available to her. For instance, she might have chosen to do additional whole group hands-on instruction instead.

Thus, while data suggested that she had increased positive perceptions about teaching science online and hands-on, she fell back on more familiar modes of instruction when challenged by factors outside her control. Her choice suggests that while Mrs. D. had an increasing interest in online and hands-on instruction, the interest had not developed into a committed plan by which to make long-term changes.

Research Question # 3

Will the design and/or the content of the unit affect the teacher's future curricular decisions? The evidence supports the hypothesis that Mrs. D. hopes to integrate more online learning into her classroom. Whether she also plans to engage in citizen science or other authentic scientific inquiry experiences is less clear.

Online Learning Future Decisions

While it should be noted that her school district decided upon the general science curriculum, there is evidence from multiple journal entries and interviews that Mrs. D. will consider a blended approach in her future curricular decisions. Not only did the teacher already significantly modify and augment existing curricula, she was looking for ways to increase student engagement and lesson authenticity using a multimodal approach (Interview, 12-9-09). Mrs. D. said:

> ... I enjoyed the online component. Because I have several of my students who learn very well that way. And what I'd like to be able to do is find a way to help kids by using the different modalities of learning; looking at the kids who do well on the computer and the kids who don't enjoy it so much, and find something that would work with those kids as well as what works online. (Interview, 12-9-09)

The caveat to implementation of more online curricula is the same as previously discussed; namely, the number and reliability of the computers in the school. Mrs. D. intended to write a grant and obtain individual laptop computers for the students. If this successful, it will greatly reduce obstacles (technological and behavioral) she faced with this learning unit. Mrs. D. indicated that with those computers she intends to integrate much more technology and online instruction into the curriculum (Interview, 12-9-09).

Thus, it is expected that if the teacher is able to obtain additional computers that reliably connect to the Internet, then she will increase the use of online technology in the science curriculum. In the event that additional computers are not purchased, it is unclear whether or not Mrs. D. will incorporate more technology into a cohesive blended curriculum, or will return to a more traditional instructional format.

Authentic Scientific Inquiry Future Decisions

The addition of the citizen science project Monarch Watch was designed to enhance student engagement and scientific literacy by creating authentic learning experiences anchored in the real world. Mrs. D. was concerned with student engagement and science literacy in the classroom. Only three of the students had strong prior science backgrounds (Interview, 12-9-09), while one student claimed to have no background:

“I've never done real science...” (Students' interview, 12-9-09). Other students fell somewhere in between.

As a part of the case study, the researcher included queries into student engagement in the lessons (see Appendix B, Prompts for Teacher Reflective Journal). The teacher was asked to determine how much of the time students were engaged (> 90%, 70-90%, 50-70%, 30-50%, <20%), and the extent to which they were engaged (*very engaged*; *engaged*; *somewhat engaged*; *not very engaged*; and *not at all engaged*). Data was recorded for three lessons; on each date students were *engaged* or *very engaged* from 50% to over 90% of instructional time (Teacher reflective journal, 9-3-09, 9-10-09, 9-17-09). Mrs. D. remarked, “I have kids that are way engaged, and kids that are disengaged.” Thus, the data suggests that the majority of the students found the unit engaging and interesting.

As to the question of whether demonstrated student engagement will encourage Mrs. D. to incorporate more citizen science projects or authentic scientific inquiry, the data is inconclusive. The Monarch Watch project was scheduled to resume in the spring and continue next fall, so clearly some additional citizen science work will be part of her curriculum. There was no discussion about integrating additional authentic scientific inquiry lessons.

<u>Blended Learning Future Decisions</u>

Data collected during the case study provided ample evidence that Mrs. D. will consider a blended approach in her future curricular decisions. Through this blended learning unit, Mrs. D. was exposed to online WISE curriculum; hands-on classroom lessons not requiring expensive equipment; the (potentially) multi-year citizen science project, and an abundance of vetted resources for her adoption. On several occasions during casual afterschool conversations the teacher indicated that she plans to explore more curricula of the type being implemented. It remains an open question whether Mrs. D will incorporate other citizen science projects besides Monarch Watch into her future curriculum.

Research Question #4

How effective is the blended unit at teaching the desired concepts? It was hypothesized that students would learn the desired concepts because the material was offered in a variety of modalities and adapted from a variety of vetted sources. Students clearly gained in their science content understanding, but it remains unclear whether these gains were truly the result of the varied approaches and varied vetted sources.

Pre and Post Content Test

Pre and post content tests and student comments provided data that supported the notion that students learned the desired concepts. Learners took a pre/post content knowledge test, consisting of 16 multiple choice and one of two alternate short-answer items to measure student learning (see Appendix B). Scores were based upon the 16 multiple-choice questions. The mean pretest score, shown in Table 8, was 4.67 whereas the mean posttest score was 7.17 which is a simple gain (posttest-pretest) of 2.5. A Wilcoxon signed rank test was used to determine the significance of this change. This nonparametric statistical test was used because the small sample size does not follow a normal curve distribution, which is required for more traditional statistical tests. A p-value of 0.05 (directional test) suggests a significant impact of the unit on student learning (W=15, N=5).

Table 8

*Summary Statistics for Student Science Pre and Post Content Tests**

	Mean	Min	Max
Pretest	4.67	3	8
Posttest	7.17	5	11

Note. Wilcoxon signed rank test; W=15; N=5

*p = 0.05

Although the change from pretest to posttest was statistically significant, students started from a low baseline and did not increase their proficiency to anticipated levels. All of the students, from grades two through seven, completed the same pretest and posttest, so it is helpful to look at gains individually to see if differences in classroom behavior or grade level might help account for the modest change (see Figure 2).

For instance, Thomas, one of the younger students, had a behavioral disorder that interfered with learning; yet his relative pre/post learning gain (from 3 to 7) was a substantial change. Lindsay and Ramona were very young; therefore the baseline was expected to be lower for those students than for the older learners. Lindsay's scores rose from 3 to 5 and Ramona's from 4 to 6. Lindsay and Ramona's changes are not all that different from Priscilla several grades above whose score rose from 4 to 6 so it is difficult to conclude that age is a major factor in the low gains. Harry is the only student who showed no learning gain. This may be related to his difficulty in adjusting from

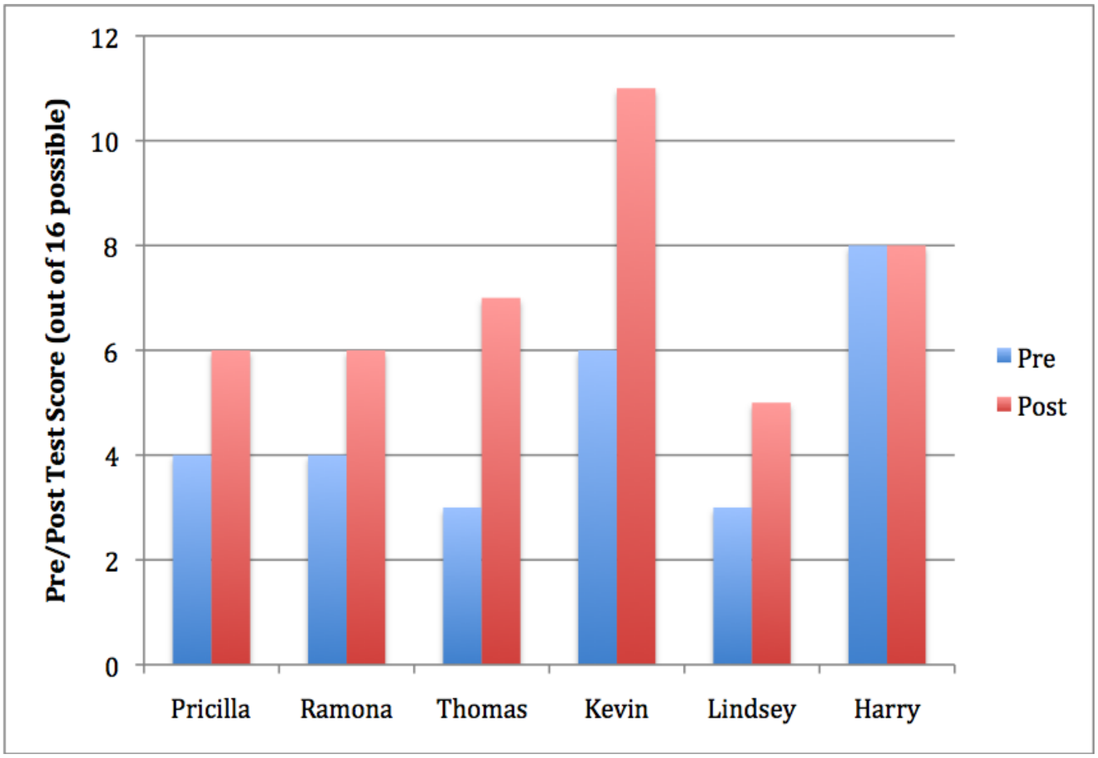

Figure 2. Students' science content pretest and posttest scores.

homeschooling to the classroom; he reportedly became acclimated to the class during the second trimester (after the end of the case study; Interview, 12-9-09).

<u>Analysis of Groups of Questions from Pre and Post Content Tests</u>

Another possible reason for not seeing the anticipated gains in pretest and posttest scores is related to different gains in different content areas (see Figure 3). For instance, the majority of the questions on the pretest and posttest were related to food webs and only two questions related directly to photosynthesis; perhaps students learned photosynthesis well and food webs poorly. Thus, the content test data was reanalyzed on a question-by-question level, looking for patterns in the pretest versus posttest data (see Figure 4).

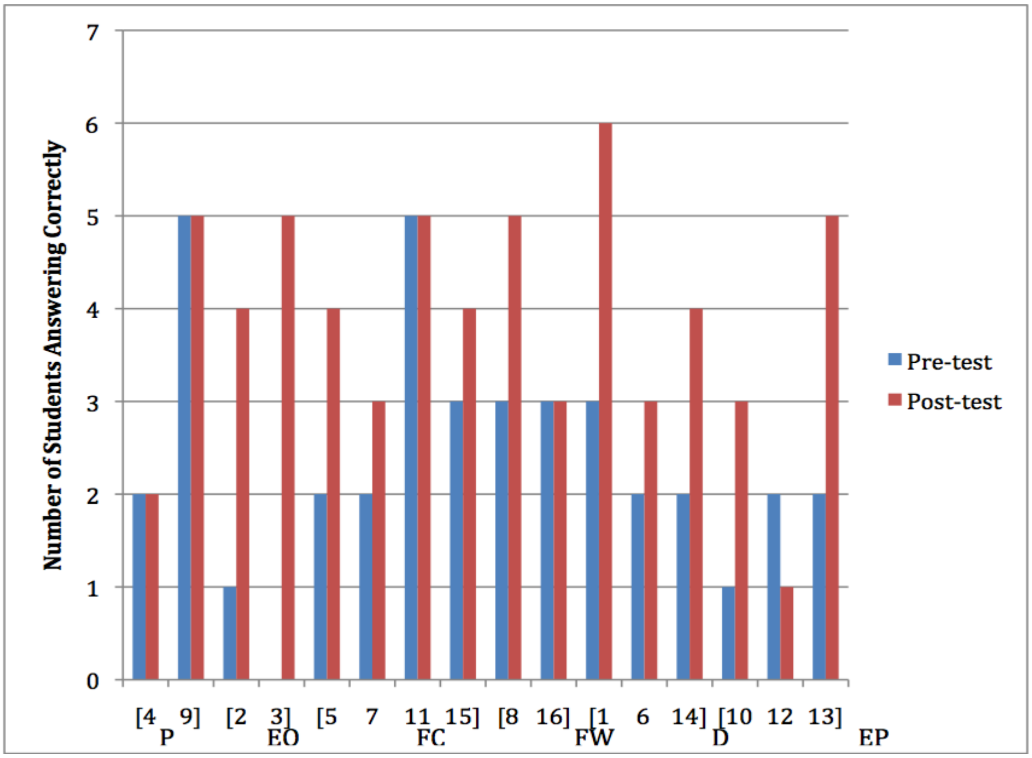

Figure 3. Science content pretest and posttest scores by category.

Note. P = photosynthesis; EO = ecosystem organization; FC = food chains; FW = food webs; D = decomposers; EP = energy pyramids

Scores increased for 11 questions; decreased for one question; and remained the same for four questions. The greatest gain in the number of students answering correctly was in response to item #3: "All of the living and nonliving things with which an organism may interact is called...." While there were zero correct answers in the pretest, five of six students answered this question correctly on the posttest. Similarly, there were 50% gains in the number of students answering correctly for item #1: "An organism that feeds primarily on the bodies of dead animals is a(n)…"; item #2: "A group of organisms of a single species that inhabit a certain region at a particular time (such as a group of

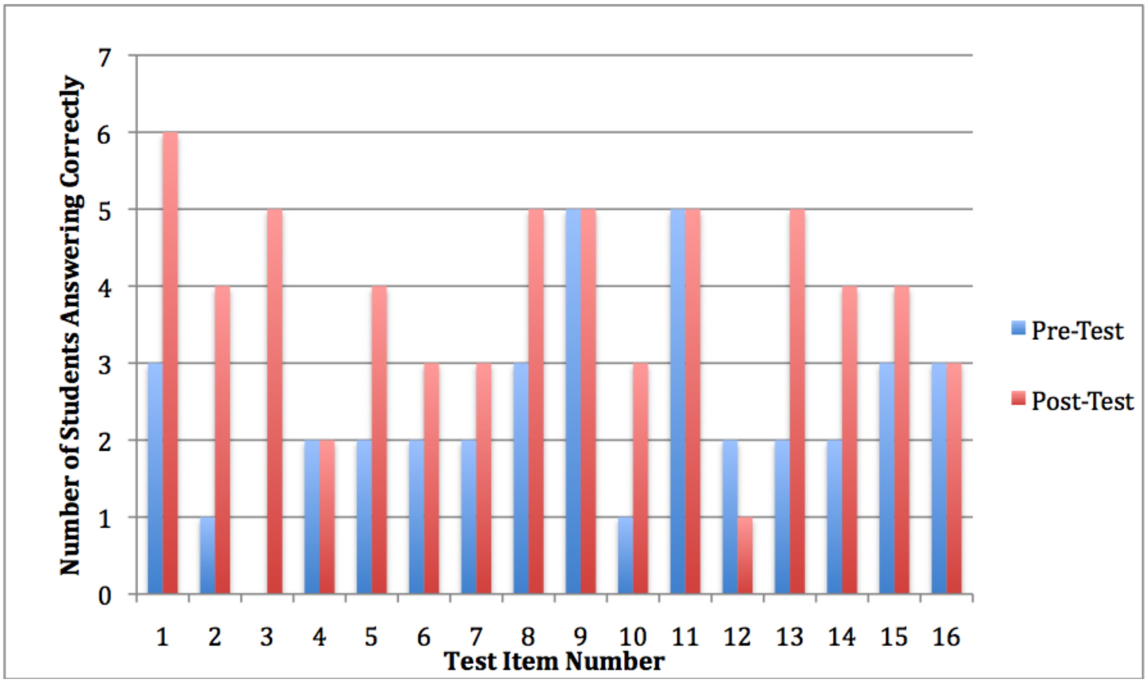

Figure 4. Science content pretest and posttest scores by item number.

students) is a(n)…;" and item #13*:* "Each level in the food pyramid is called a…." There was a 33% gain in the number of students answering correctly in response to questions related to identification of specific decomposers (item #1) and herbivores (item #5) as well as the proper placement of organisms on trophic levels (item #10) and within food webs (item #8). Of the three questions for which there was a one-student gain, two reflected technical details of food chains (items #7, #15) and one question tested an understanding of an organism's total contribution to the ecosystem (item #6).

The sole question in which there was a decrease in score, (item #12): "Another name for the organism that eats an herbivore is the..." appeared to be the result of teacher confusion between terminology about what an organism eats and where it resides on the energy pyramid. Of the 4 answer choices: (a) secondary consumer, (b) primary consumer, (c) producer, (d) decomposer, on the posttest, one student chose answer “a” (correct answer), three students chose answer “b,” one chose “c,” and one did not answer the question, which was scored as an incorrect answer. Mrs. D. informed the researcher that she had misspoken when describing the relationships between the terms *herbivore* and *primary consumer* and *carnivore* and *secondary consumer* in a review session before the posttest, but had corrected the mistake just before the test was taken (Research journal, 10-30-09, Interview, 12-9-09). The number of incorrect answers on this item suggests that either: (1) the students remained confused about these relationships, or (2) that Mrs. D.’s “corrected” answer was in error and the students used the wrong information to answer item #12.

There were no changes in learning for four questions. Two of those questions (items #4 and 9) related to photosynthesis and two (items #11 and 16) to food chains.

Only two photosynthesis questions were included in the test, and neither showed a change in pre/post score. There remained confusion about the gases that plants use for photosynthesis and only two of the six students answered correctly. The four incorrect answers were evenly split between *carbon monoxide* and *oxygen*. Oxygen remained an answer, even after substantial time was spent learning about the relative roles of carbon dioxide and oxygen in the photosynthetic process. It is suspected that the familiarity of the word *oxygen*, as compared to the introduction of the novel term *carbon dioxide* led to this result. Two students chose *carbon monoxide*; it is suspected that the similarity in name to the correct answer (*carbon dioxide*) accounts for this choice. By contrast, five of the six students recognized that plants produce their own food (item #9) at both the beginning and the end of the unit.

Thus, there were few generalizable patterns on a question-by-question analysis of the data. All of the questions that showed the greatest change, with over half of the students learning the correct answer by the end of the unit, were simple vocabulary questions of the "Which of the following meets this definition…" variety. These were also the most straightforward questions on the content test, thus it is not surprising that students would perform better on simple questions versus multi-layered questions (such as item #12) or conceptual questions (such as items #8 and 10). The types of questions that showed learning gains were broadly scattered over the range of conceptual areas (vocabulary, ecosystems, food webs, decomposers, trophic levels, etc.), not just a single topic. Students showed learning gains in the food webs section of the curriculum even though the online part of that section was not required by the teacher. Although there were no gains at all on the only two questions were related to photosynthesis, it was clear that five of the six students clearly understood the main point of photosynthesis – that it is the process by which plants make their own food. The only possible remaining pattern may be that students did not learn about food chains as well as the other topics; of the five questions related to food chains (items #7, 11, 12, 15, and 16), two showed improvement by only one student, two showed no improvement, and one showed a decrease. Yet that alone does not seem sufficient to account for students' overall having on average a gain of 2.5 correct answers on a 16 question test.

<u>Looking for Deeper Conceptual Understandings</u>

Another possible reason for lower than expected gains on the pre/post test is related to the nature of the test. It is a 17-question standardized, multiple choice and short-answer test drawn from multiple instruments. Therefore, it is by its very nature focused on vocabulary acquisition. That students performed best on vocabulary questions is consistent with this view. Perhaps there was deeper conceptual understanding that may be revealed in other formative and summative assessments, or in students' Reflective Journals. Unfortunately, no other documentation revealed that deeper level of conceptual understanding.

There were no gains on an open-ended photosynthesis question included on the pre and post content test (item #17). The question presented students with data from an experiment in which seeds were planted and grown in dark versus light conditions and then asked students to explain why the seedlings grown in the dark were taller than seedlings grown in the light. A lesson plan related to this material was included in the unit as a summary activity, but this portion of the curriculum was not implemented. It was clear that students' responses changed very little, remaining fairly accurate ("It was trying to get to the sunlight") yet imprecise about the mechanism behind, and the importance of, this difference. Student responses to the test item are shown in Table 9.

In addition to the pre/post concept tests, some students drew diagrams showing energy pyramids, photosynthesis, and food webs. Unfortunately, not all students completed these assignments due to a printer error. A review of the available documents produced anecdotal evidence of gains in content knowledge in two of three areas: Three out of six students who completed energy pyramids drew (mostly) correct diagrams; three out of six students who completed a photosynthesis diagram did so correctly, including the proper places of carbon dioxide and oxygen in the photosynthetic cycle. However, students clearly did not understand food webs well enough to diagram

Table 9

Pretest and Posttest Answers to a Photosynthesis Open-ended Question

Student	Responses to photosynthesis question: Pretest	Posttest
Kevin	It is growing quickly to try to find light.	It is growing quickly to try to reach sunlight.
Lindsay	It was trying to reach the sun.	It was trying to get to the sunlight.
Harry	Because the plants were dying and looking for sun.	Because pot B was searching for light in a dark room.
Priscilla	The plant in pot B is taller because she didn't give it sunlight.	Pot B was in darkness and pot A was in sun.
Ramona	no answer	Put in a dark room.
Thomas	No sun!	‘Cause [sic] had no sun.

one: Of six students who completed this assignment, none correctly diagrammed food webs.

This suggests that students were able to retain information regarding simple ecological relationships that are easily asked on multiple choice tests; however, there was no deeper conceptual understanding as would be needed to diagram the more complicated relationships found in a food web.

Several comments from Student Reflective Journals reveal that students were engaged in the learning process (and to the reflective writing process) to varying degrees and learned things on a range of different topics. To the prompt, "What I learned today," the following responses were recorded:

- "Monarchs birth. Monarchs have 30 eggs at a time." Girl, Grade 7
- "Photosynthesis is how the plants make food. Glucose is a sugar. Root hairs are the hairs that come off of roots that absorb water." Boy, Grade 7
- "Photosynthesis is making food and plants." Girl, Grade 7
- "I learned that yeast is a fungi." Boy, Grade 5
- "I learned that a herbivore is a primary consumer, not a secondary consumer." Boy, Grade 5.
- "Mold is growing in my column." Boy, Grade 4.

<u>Reasons for Unit Efficacy.</u>

It was hypothesized that gains in student learning were the result of the careful design of the unit, blending hands-on and online lessons from a variety of vetted sources. The available data provided evidence of modest, yet statistically significant, gains in student learning. However, the small sample size and significant modifications to the unit's implementation make it difficult to draw a causal link between the design of the blended unit and student learning. Since students at the end of the unit aren't performing as anticipated by the standardized test measures, nor can we document wide-spread deeper conceptual understanding by the majority of the students, we are left to ponder whether the unit itself may be flawed in its design or whether the delivery of the unit failed to maximize its potential. These possibilities are fully discussed in the Summary and Conclusions section.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Purpose

The purpose of this research project was to evaluate the effectiveness of a blended science unit, composed of both online and classroom curriculum, on teaching and learning in a rural, single classroom schoolhouse. The project was developed to respond to the needs of teachers in this unique K-8 educational setting by providing a comprehensive life science unit packaged for immediate implementation but flexible to meet instructional and learner needs. This project consists of two parts: A blended ecology unit created for middle and upper elementary grades, and a case study testing the unit's efficacy in a multiple-subject, multiple-grade classroom.

Scope

The ecology unit consisted of an eight week, interactive, series of hands-on and web-based activities scaffolded to support conceptual understanding of the flow of energy through the ecosystem. The learning goals included student understanding of: Photosynthesis as a process resulting in oxygen and energy, two products necessary to sustain life on Earth; the interdependence of organisms in the biotic ecosystem; and the way a representative organism interacts with and depends upon that ecosystem.

The case study was conducted at a small, rural, faith-based, K-8 elementary school in Northern California. Six students and the educator participated in the study. Research goals sought to answer four questions and the subordinate hypotheses. Questions included: What effects will using a blended science unit have on the teacher's confidence about teaching science content; what effects will using a blended science unit have on the teacher's perceptions about teaching science; will the design and/or the content of the unit affect the teacher's future curricular decisions; and how effective is a blended unit at teaching the desired concepts?

Significance and Limitations

The project contributed to the body of knowledge in an area of science education in which there is a dearth of research data. Most studies of blended learning in the classroom have been aimed at determining the efficacy of course-level blended curricular choices made in the post-secondary educational setting. By contrast, this study focused on the efficacy of adding unit-level blended curriculum to the multiple-grade, multiple subject elementary classroom. Limitations of the project included the small sample size of participants in the case study and computer malfunction, which impacted availability of technology during implementation of the learning unit.

Results

A blended learning unit was created and is available online (http://web.me.com/westbie/energy). The unit was designed to meet key science standards and to address issues of limited time, science proficiency and resources faced by elementary teachers, including Mrs. D.

Case study data was collected to address each of the research questions. In summary:

1. Teacher confidence: While there were substantial gains in some of the Personal Science Teaching Efficacy Beliefs areas, there were losses in Science Teaching Outcome Expectancy. Qualitative evidence supports the idea that the decreases in Science Teaching Outcome Expectancy are because the teacher believes that students share some of the responsibility for learning. There was clear evidence that providing a packaged curriculum would not, in and of itself, necessarily result in the implementation of the unit as designed.

2. Teacher perceptions: Mrs. D. clearly benefited from the blended unit's flexibility to address immediate classroom logistical problems. However, she fell back on more familiar modes of instruction (e.g. direct instruction) when continually challenged by behavioral disruption, computer and Internet problems, and a lack of classroom assistance. This choice suggested that while the educator had an increasing interest in applying more online and hands-on instruction, her interest had not developed into an action plan that would accomplish long-term changes to her science curriculum.

3. Future curriculum decisions: Mrs. D. clearly established her intent to integrate more web-based science learning, with the stipulation that additional, reliable computers are made available to the students. Whether she also planned to engage in future citizen science projects or other forms of authentic science inquiry is less clear: While the Monarch Watch project was scheduled to remain part of the curriculum through Fall 2010, there was no specific discussion about integrating other citizen science

projects or authentic science inquiry experiences beyond any that may be offered through periodic educational field trips.

4. Student learning: While there were modest yet statistically significant gains in student learning, the small sample size and significant modification to its implementation make it difficult to draw a causal link between the design of the blended unit and student learning. Furthermore, students at the end of the unit did not perform as anticipated on the standardized test measures, nor could widespread deeper conceptual understanding be documented for the majority of students. Flaws in the unit design itself and/or delivery of the unit that failed to maximize its potential must both be considered.

Conclusions

Conclusions: Initial Unit Design

This project resulted in the successful completion of a blended learning unit that addressed key district, state, and national science standards and addressed multiple learning styles by bringing together the major advantages of hands-on classroom learning and online education while mitigating their drawbacks. In addition, this unit sought to specifically address misconceptions commonly held by elementary children. Furthermore, the unit was designed to address the difficulties encountered by Mrs. D. and other elementary teachers (Dorph, et al., 2007). These difficulties include limited time and proficiency (Dorph, et al., 2007; Klahr & Li, 2005; NRC, 2007), as well as limited funding and resources (Dorph, et al.; NRC, 2007; USDOE, 2009). The unit addressed all four of these issues and further addressed issues that the teacher brought up as concerns.

Misconceptions. To address the misconceptions that heat from the sun drives photosynthesis (Berthelsen, 1999) and that the main job of the leaf is to capture the warmth of the sun (Wandersee, 1986), students participated in a three-week exploration (see Appendix A, "Is Sunlight Necessary for Photosynthesis?"), in which leaves from six similar plants were compared for photosynthetic activity. Some of the leaves were partially or fully masked for various lengths of time. In this way the leaves would receive the same amount of heat, but different amounts of sunlight exposure. After one week, leaves were uncovered on two plants; uncovered leaves were compared to other leaves on the same plant, the other treated plant, and the control plants. After two weeks, the final group of leaves was compared per plant, against the first group of treated plants (to see if the leaves had resumed photosynthesis) and the control plants.

It was expected that students would see light areas where the leaves had been covered, with a greater difference in leaves covered for two weeks than one week. This experiment showed that sunlight, not heat, is necessary for photosynthesis. Through daily class mini-discussions the teacher helped students work through other ideas or confusion. After the class had completed all of the photosynthesis content both online and in class, a whole class "wrap up" discussion was scheduled to answer lingering questions about the basics of photosynthesis.

To address the misconception that an increase or decrease in one organism's population along the food chain will affect only other organisms on the same chain, not those along a different energy route (Griffiths & Grant, 1985), students were directed to the *Rainforest Interactions* unit at WISE (http://wise.berkeley.edu). As previously noted, Mrs. D. omitted this portion of the learning unit. The WISE lessons were selected to allow students to virtually practice creating food chains and food webs and study the interrelationships of the organisms inhabiting them in an interactive, scaffolded way. In this sequence learners create a virtual local food web (beginning with the pupil), run a simulation to try to obtain a sustainable simple food chain (figs, monkeys and eagles), then enter the Costa Rican rainforest. There they select and conduct background research on an endangered animal and then create a detailed, extensive food web for that animal. Learners are encouraged to find not only what their animal eats (a simple food chain), but what things others in the food web eats, and so on until they have a "spider web" of organisms. All components of the lessons are supported by online notepads, a discussion board, and presentation tools that help students keep track of and discuss the material.

The formation of the endangered animal's food web allows students to create hands-on the interactions and interdependence that they have read about throughout the sequence of lessons. The anticipated next step was the transfer of students' new understanding from the WISE site to the Monarch population next season, thereby applying that knowledge across the digital divide to the physical world. Applying these ideas to Monarchs was expected to produce the desired deep conceptual understanding about energy flow through ecosystems, the ultimate goal of the unit. While the teacher's role was as facilitator during *Rainforest Interactions*, the extended nature of the Monarch Watch project will necessitate a periodic review of these ideas to keep them fresh and help students make connections with the real world content as they are investigating the butterfly.

Limited time and proficiency. The packaged unit design considerably reduced the time required for science curriculum preparation to only the time necessary to review the concepts, copy the lesson plans and supporting documents, and collect any classroom materials that were needed. All of the information needed to implement the unit was included on the website under *Teacher Resources*. Limited proficiency was addressed through the use of an abundance of supportive materials, including: Subject matter background articles; website links; lesson plans and accompanying materials; and ideas for additional classroom activities.

Limited funding and resources. The unit cost very little money and required very few resources to implement. Lesson plans were selected such that the majority of the materials needed were basic classroom supplies already available to the teacher; e.g., tinfoil, masking tape, paper clips, etc. The most expensive part of the hands-on activities came in the photosynthesis section and was the purchase of six plants with comparable physical characteristics. In fact, these plants could be grown from any readily available seed such as dried beans from the grocery store, thereby saving even these minimal costs. The other unusual materials included empty 2- and 3-liter soda bottles that students brought from home for making the decomposition columns and Monarch Watch Waystation seeds that were donated to the class by the researcher. If seeds had been purchased from the Monarch Watch website, the cost would have been approximately $24. However, many of the seed packets could have been purchased locally for a significant cost savings.

A more difficult challenge to overcome was the ongoing struggle with technological dependability. Four student computers were insufficient, and Internet connectivity was unreliable. Without on-site technical support, sudden malfunctions that would constitute a small annoyance in a class containing a large number of working computers became a hindrance in a class with just a few computers that must be shared among students - especially students who have little to no computer access at home. For instance, two computers malfunctioned on the same day, which resulted in a sudden 50% decline in computer accessibility and necessitated a considerable reworking of the day's lessons.

Resolving the greater issues of access and support (Hew & Brush, 2007) was beyond the scope of the study, but constituted an advantageous research environment in which to test the functionality of a blended science unit. Mrs. D. is certainly not unique among elementary teachers in having few functioning computers in her classroom. The unit's blended design was expected to mitigate hurdles to access and support by providing hands-on activities and other classroom-based activities, a strategy that would avoid immaterial seat work prompted by computer downtime. Even the impact of prolonged Internet inaccessibility could be remedied (or at least lessened) by hands-on activities; the primary exception would be the inability of students to access the WISE site and engage in the inquiry lessons intended to lead to a deeper conceptual understanding of food chains and food webs. While problematic, this need not be an intractable obstacle because the remaining functional computers could be accessed individually by students at other times during the school day as a homework assignment. Therefore, the blended unit provided the flexibility to deal with technological issues through the inclusion of a variety of learning activities from along the pedagogical continuum.

Teacher Input. Over the course of several weeks, prior to the start of the school year, the unit was incrementally modified to respond to curricular needs as they were identified. For instance, during the development of the learning unit Mrs. D. was consulted to check that the context and content of the learning materials were consistent with the specific needs of her curriculum, i.e., that none of the proffered material would be considered offensive to the students and their families (websites referring to monsters, such as Science Monster, were excluded from the unit). Thus, the design of the unit reflected the specific curricular needs of this classroom.

Conclusions: Case Study

Given that the design of the learning unit addressed student ideas; resolved issues of limited time, proficiency, resources, and funding; mitigated the effects of computer malfunction; and was subjected to review and incremental improvement based upon educator feedback, it was expected that the case study would reveal that the learning unit had effected positive changes in teacher confidence, perception and future curricular decisions, and resulted in student learning gains. However, the study yielded mixed results in each area.

Teacher confidence. There were gains in Personal Science Teaching Efficacy Belief but losses in Science Teaching Outcome Expectancy. The evidence suggests that Mrs. D. became more confident about her ability to teach science but less confident that her teaching would significantly impact student learning. This change in outlook reflected the changing dynamics of the classroom from the “honeymoon” stage at the beginning of the school year to the “real” interactions among students, including those with behavioral, emotional and learning disorders. Over time, Mrs. D. held students more accountable for the choices they made (e.g., to cooperate with group members or walk away and refuse to participate; to turn in homework or "lose it" in the desk; to work productively or be disruptive), while maintaining an overarching, and in fact increasing, sense of responsibility for student learning. Riggs' Science Teaching Outcome Expectancy scale was designed to measure whether someone believed that his or her actions, in this case a teacher's pedagogical and curricular choices, would lead to the desired outcome, in this case student learning. It was clear from Mrs. D.'s comments on following the outcome expectancy questions that her decreased score was not related to the curriculum; rather, the onus lies on students to meet her half-way. With constant behavioral distractions, there are behavior modification strategies she could and did employ to help mitigate the problems, yet ultimately Mrs. D. clearly felt that the students share some responsibility for learning as well.

<u>Teacher perceptions.</u> As previously discussed, Mrs. D. exhibited an increased interest in online and hands-on content on multiple occasions, but resorted to a traditional teacher-centered approach when faced with challenging conditions. Mrs. D.'s choice to use direct instruction during the food webs portion of the unit was precipitated by four major factors. First, computer functionality, and therefore Internet access, remained inconsistent. Second, student behavior, particularly the interpersonal interactions of two children, continued to cause classroom disruptions. Third, though she had been introduced to WISE during the creation of the learning unit, Mrs. D. was not proficient on the use of the website and felt unable to provide technical support if problems arose: "I didn't really get my hands around [WISE], and so I wasn't able to really share with them well how to use that site…" (Interview, 12-9-09). Fourth, there was no other adult in the classroom during the food webs portion of the unit to help mitigate these issues.

An additional minor factor may have played a secondary role; for two days older students participated in a simulation about the Andersonville prison in social studies, and were segregated ("imprisoned") from younger students. As learners were already segregated by into upper and lower grades and the movements of the "prisoners" severely curtailed, direct instruction was chosen for science during that time. Although this may contribute to the explanation for why direct instruction was chosen, it is really a secondary consideration. The social studies unit took place over a period of four days, only two of which included science. Furthermore, it accounts for only one out of four weeks of science instruction under consideration.

It is therefore clear that the interaction of the primary four factors created challenges to the implementation of the unit as designed; yet, there remained other options besides a return to direct instruction. For instance, perhaps one of the classroom volunteers could have been requested to assist during science time, thus providing the second adult to help solve technical computer issues or redirect disruptive students to more productive activities. Another option available, even without a second adult, was the inclusion of more whole-class hands-on activities: "Food Chain Checkers" and the "Food Chain Game, two group games that simulate changing dynamics in a food web were immediately available via the website (http://web.me.com/mwestbie/energy) but were ultimately not implemented.

From a design standpoint, perhaps the unit could have provided more teacher resources to guide teachers new to the WISE site through the activity sequence. But given the other issues, this probably would not have changed Mrs. D.'s choice; rather, it was the combination of factors that led to her decision. Thus, it appears that the basic, underlying reason that direct instruction was chosen was that this approach was considered a dependable and safe instructional strategy during challenging classroom conditions.

Future curricular decisions. Mrs. D. was very reluctant to commit to adding more online learning experiences without adequate and reliable access to the Internet. Unfortunately, her experience implementing this unit was that persistent computer problems substantially disrupted her planned curriculum, to such an extent that contingency plans were always necessary. Without drastic changes, she had no reason to believe that future curriculum would be any less affected. If her future grant application for computer equipment is successful, then this will resolve the problem of unreliability and allow all children access to interactive activities to keep them focused, thereby reducing the amount of disruptive behavior in the classroom.

It is unclear why no other citizen science or authentic inquiry projects were planned, other than perhaps to give the class a chance to complete the Monarch Watch butterfly studies and then evaluate the project's effect on student learning. Several other projects were casually discussed but not included as part of the teacher's resources. Even if a list of other relevant citizen science projects had been provided as part of the curriculum, it is unclear if Mrs. D. would have chosen to engage her students in these. She never seemed to fully appreciate the value of authentic inquiry experiences for her students and instead seemed to consider the Monarch Watch project as an extended hands-on experience. Mrs. D. also talked about field trips as a form of hands-on learning; it is not clear whether she equates all hands-on learning with authentic inquiry experiences, as the differences between hands-on and inquiry learning were not expressly discussed.

Student learning. As previously discussed, the modest gains in student learning were consistent with superficial knowledge acquisition rather than deep conceptual understanding. This may be the result of flaws in either the unit or implementation of the unit. An illustrative example of this difficulty in interpretation may be seen in the food webs section, which was significantly modified when the teacher chose to use a direct instruction approach for the classroom lessons and made online exploration of food webs on the WISE site an optional, student-driven activity. Student test data showed that students had statistically significant gains in learning on a standardized test but that these gains were modest – from near chance at 25% to perhaps 40% - a gain of 2-3 questions on the 16-question multiple subject section . Food chain and food web questions showed little gains when analyzed on a question-by-question level. No further evidence of deeper understanding is found by looking at the qualitative student data. The WISE activity was included in the curriculum design to promote deeper understanding and address student misconceptions about food chains and food webs, but was not required by the teacher. The remaining hands-on and direct instruction pieces were clearly insufficient to promote the levels of student learning desired.

Because the entire unit wasn't taught as envisioned, it is difficult to evaluate the quality of the unit and consider improvements to the unit for the future that might further enhance student learning. The WISE activity was never taught; without the online portion, the other food webs material may have led to student confusion and misunderstanding. Moreover, classroom activities that would have explored food webs in a physical manner (i.e., through games and whole-body simulations) were not used. Student food web diagrams suggest that learners were unable to correctly represent these relationships because: (1) they did not practice making food webs; and/or (2) they did not understand relationships between organisms.

As this was the first and only test of the unit's efficacy, there is no other trial data in which the WISE activity was implemented with which to compare the current results and determine more conclusively whether the unit as designed (but not as implemented in Mrs. D.'s classroom) would have increased student content understanding to the desired levels.

Further discussion

Mrs. D.'s choice to significantly modify the latter part of the learning unit was the most surprising outcome of the study. Whether she should have implemented the unit as designed is a question that has arisen in hindsight; at the time the unit was designed this issue never arose.

There are four major views of curriculum that are frequently encountered in the literature. The first, known as "teacher-proof" curriculum, contends that teachers in general, and elementary teachers in particular, are extremely underprepared in science and require curriculum that tells them specifically, step-by-step, what to do (see for example, Stein, et al., 1998). This view assumes that there is a singular "right way" to coordinate and teach the curriculum; if the implemented curriculum epitomizes this correct way, then it will lead to student learning. The majority of what is available today from traditional publishers and other sources is tightly scripted in this way (Kesidou et al., 2002; Lumpe, 2008).

Another view opposes prescribed curriculum, and asserts that only the teacher knows students' learning needs well enough to make on-the-spot modifications to the learning environment in response to those needs (see for example, Sawyer, 2004). Therefore, educators ought to develop their own curriculum. Because so many teachers are underprepared to teach science, however, innovative curriculum is seen as a temporary, necessary evil until such time as sweeping professional development can correct this deficiency.

A third view sees formal curricula as reference material (see for example, Tobin and Dawson, 1992). Since educators do not have the time or energy to create a complete curriculum for every subject they teach, they need a good reference library from which to draw material and develop something unique. Prepared curriculum constitutes this reference library. From this perspective science teachers are exposed to new ideas through prepared curriculum, but remain in creative control in the implementation of their personalized curriculum.

A final position proposes that the best approach is a partnership between the teacher and the curriculum (see for example, Lumpe, 2008; Russell, 1997). This view recognizes that both bring valuable contributions to curriculum development. Most science teachers are unable to create a complete, sound curriculum on their own. However, they are in the classroom to observe, assess and modify the curriculum in response to learner needs.

This work adopted a view towards curriculum development similar to that of Lumpe (2008) and Russell (1997): That there should be a partnership between the teacher and her curriculum. Curriculum should not be scripted, nor should it be entirely teacher-designed, nor should it be a reference material. Three assumptions were made in considering the implementation of the blended curriculum unit: (1) The teacher would follow the broad outlines of the unit and teach about photosynthesis, food chains and food webs, and Monarch butterflies; (2) the teacher would use the majority of the classroom activities but was free to select individual items to add or subtract or reorganize as needed; (3) the students would view all of the online material.

Moreover, it was expected that the Mrs. D. would focus the majority of her attention on the classroom activities; students would interact with the online media independently and in small groups, while the teacher provided general oversight and intermittent assistance. In this way, the teacher would have more freedom to move among the students and offer differentiated curriculum to the learners, depending upon grade level and abilities.

The researcher assumed that the teacher, who expressed concern about her ability to teach the subject, would depend upon on the packaged curriculum to provide pedagogical content knowledge to maximize student learning. The teacher, having access to all of the material, apparently viewed the various components of the unit as equally important and therefore interchangeable. There was no evidence to suggest that she equates direct instruction with online or hands-on learning; rather, she made it clear that her decision was based upon circumstances in the classroom rather than a sudden shift to a different pedagogical perspective.

To illustrate this difference in underlying assumptions further, the researcher merely noted that Mrs. D. chose to implement “Monica Monarch” instead of “Gulliver's Story” for the active reading sequence, because the stories were equivalent in activity type. However, the researcher was surprised that Mrs. D. chose to pursue direct instruction in lieu of the WISE units because those were not equivalent activities.

The educator did have a strong preference for selective implementation of curricular materials, taking a “curriculum as reference material” outlook; this was a style adopted over several years of teaching, and with which she was comfortable. Moreover, in her present position the reference material strategy allowed her to select a variety of materials to accommodate a range of grades for whole-class lesson planning. Thus, she experienced success in utilizing this method of curriculum development, which may explain why she did not implement the packaged unit designed for her class and instead modified the curriculum as a matter of routine.

However, every teacher has general education subjects with which they are the most and least comfortable teaching. For Mrs. D., these were social studies and science, respectively. Sloan (2006) pointed out that tension between carefully crafted curriculum on one hand and teacher autonomy on the other plays out in different ways depending on a teacher’s experience, identity and attitudes. Experienced teachers often find scripted curriculum and district-imposed accountability policies oppressive and counter-productive. In contrast, new teachers and those with a weak content or pedagogical understanding may see scripted materials as supportive, especially in the short term while they develop a larger knowledge and skills base (Sloan, 2006).

Given Mrs. D.’s lack of background knowledge and confidence in teaching skills in science, she would have benefited from using the proffered structured curriculum as a scaffold upon which to build additional pedagogical content knowledge in this subject matter while teaching science through the additional modalities of authentic inquiry learning, hands-on learning, and online learning. Having an intensive experience with the material would have provided her with context, content knowledge, and the time to practice teaching strategies more commonly associated with professional development modules that the more haphazard approach of improvising, or selecting from a reference library of activities, is not able to do. In addition, the completion of the unit as designed may have significantly raised the teacher’s confidence in teaching science and perceptions about teaching science in a way that her current approach did not. Finally, the completion of the unit as designed may have helped students better achieve the desired learning goals.

Although it is this researcher’s belief that Mrs. D., due to her lack of confidence and content expertise with science, would have benefitted from following the curriculum unit more or less as designed, the curriculum is not scripted and is not intended to be teacher-proof.

Recommendations

The primary recommendation is that teachers, especially in challenging environments, understand that personal and curricular resources are available online. For instance, this learning unit is readily available (http://web.me.com/mwestbie/energy). Another suggestion, pertinent to curriculum designers, is that to the greatest extent possible the developer should forge a strong working relationship, a partnership, with the teacher(s) who will be using the curriculum. Lack of communication between designer and educator offers valuable insight: The most surprising outcome of the current case study was the teacher's decision to forgo a major part of the online curriculum. Because the teacher shared information about the inner workings of her classroom and how those factors influenced her decisions while implementing the curriculum, she provided a real-world context that can aid future designs. Curriculum that most closely matches the real needs of the classroom is more likely to be implemented by the teacher in the way it was designed. To this end, the designer/researcher could have improved communication between the designer and educator in this project by: (1) Describing the designer's theoretical perspective of curriculum development as a partnership; (2) eliciting the teacher's theoretical view about curriculum; (3) explaining which components are central to the unit and which are not; (4) providing the educator with support materials to make accessing and navigating the WISE sequence more clear and easy; and (5) providing a list and description of appropriate citizen science projects.

If this project were to be repeated, it is recommended that schools similar in size, structure, and challenges be selected. Blended learning in challenging environments remains an important option, and perhaps the only option, in which teachers with unreliable computers will feel any confidence about adding online content. The unit should be revised to clearly communicate the salient components and describe what can be exchanged or deleted without potential detriment; the teacher should then flexibly implement the unit within those constraints. This will allow collected data to clearly determine the unit's role in changes in the teacher's confidence level, perceptions, and curricular decisions, and to student learning.

It is further advised that the unit be followed farther into the school year, after students have had a chance to develop reflective writing skills and had the opportunity to apply their new ideas to the Monarch Watch project. Content tests should be supplemented by other evidence of learning, such as research journals, that are useful in showing continual change over time. Assessment measures should be preprinted and brought in with the researcher to avoid printer errors in the hectic environment of the school.

Above all, the researcher should look for nuances in the culture of the school that makes it a unique and exciting place to be. As was discovered during this study, students who are excited and proud of their learning environment are much more willing to share their experiences and learning with an outside observer.

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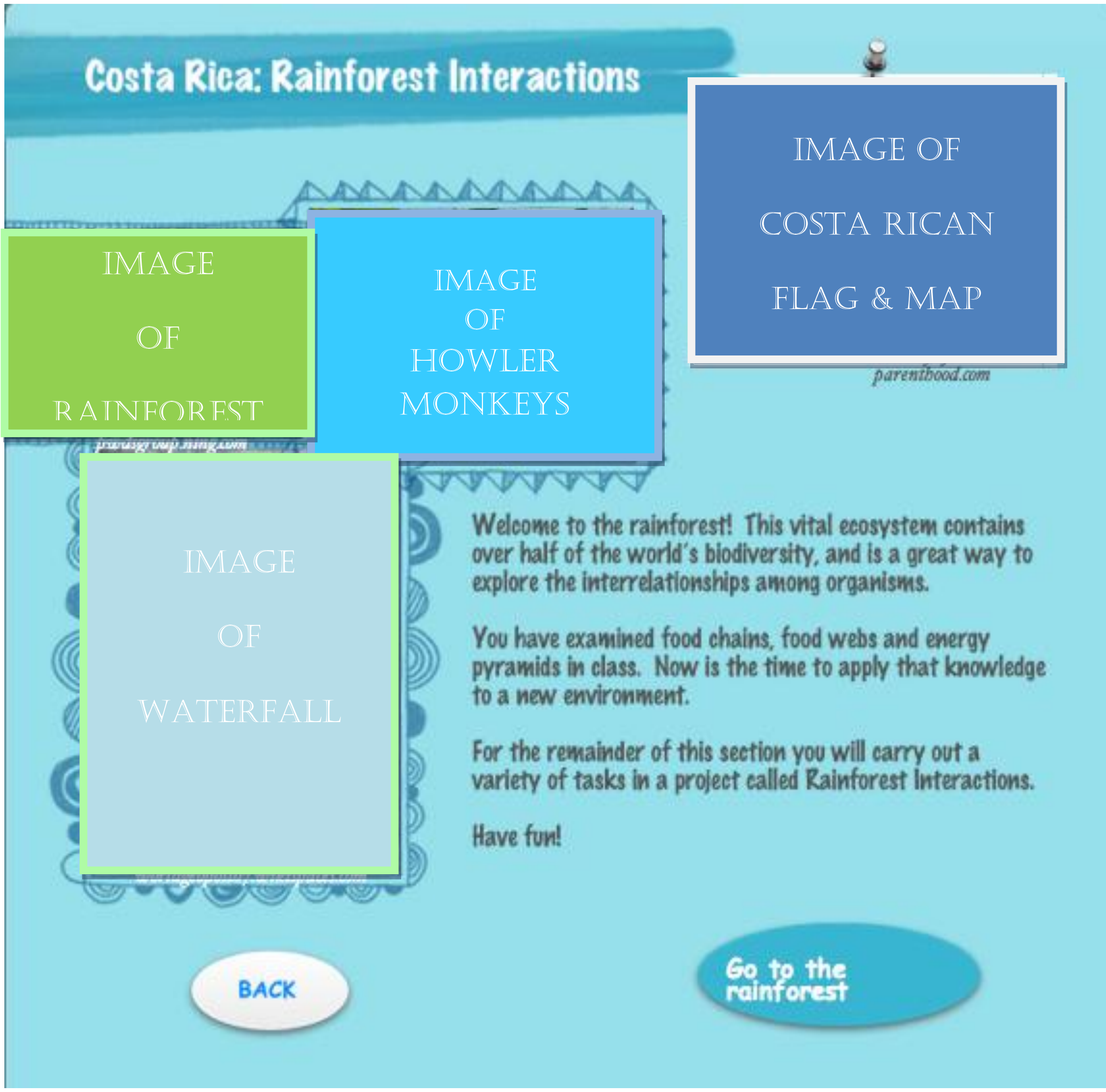
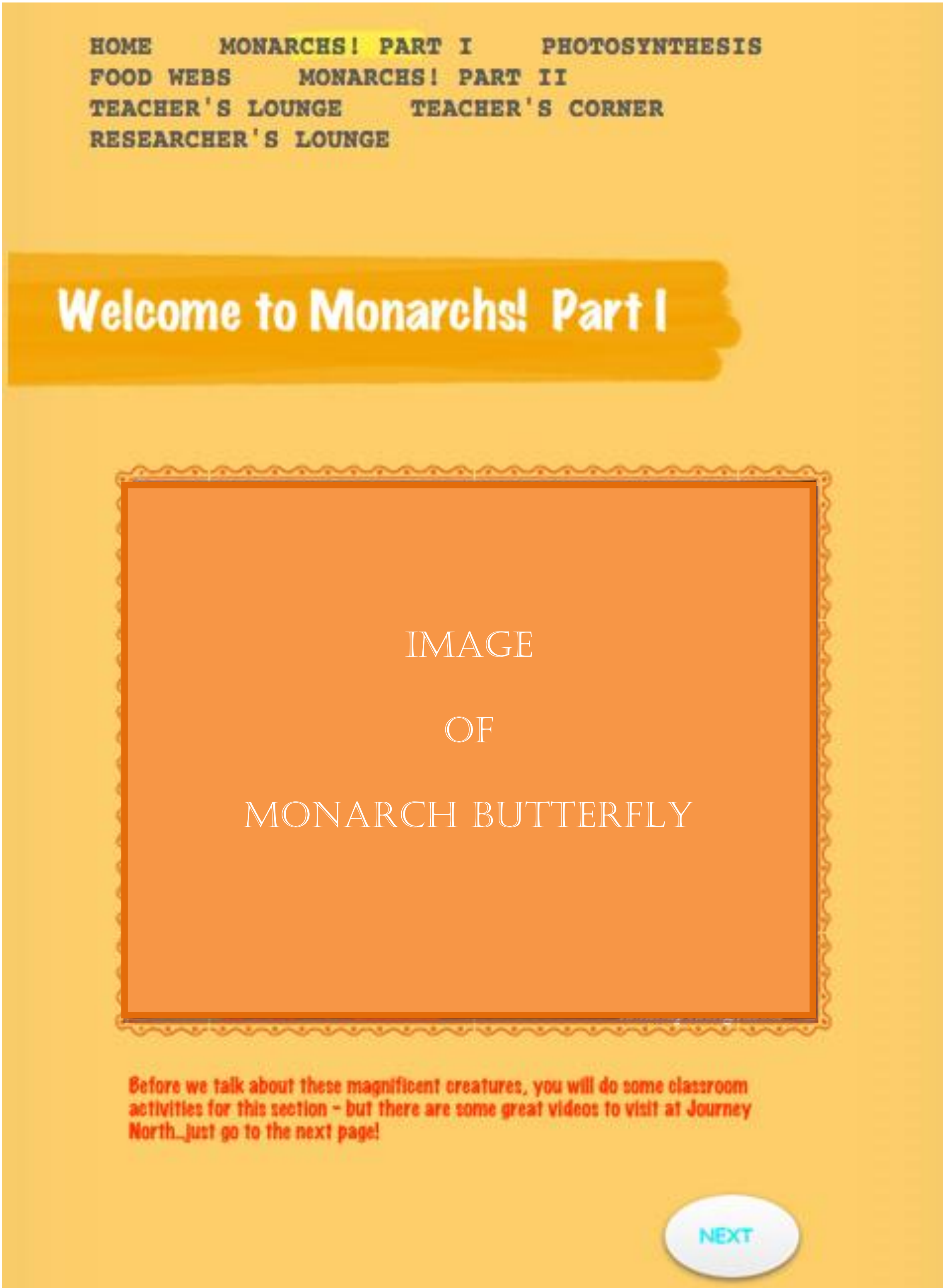
APPENDIX A

http://web.me.com/mwestbie/energy


HOME MONARCHS! PART I PHOTOSYNTHESIS
FOOD WEBS MONARCHS! PART II
TEACHER'S LOUNGE TEACHER'S CORNER
RESEARCHER'S LOUNGE
Welcome to Photosynthesis
PHOTOSYNTHESIS: THE PROCESS IN WHICH PLANTS MAKE THEIR OWN FOOD
IMAGE LINK
TO
"THE PHOTOSYNTHESIS SONG"
0:00 / 1:52
video courtesy of YouTube
What's so special about photosynthesis?
Without photosynthesis you could not live. All of life depends upon this fundamental process. In this section you will explore how plants and some bacteria use energy from the sun, carbon dioxide from the air, and water from the ground to make their own food.
Before you start this topic, take this 10-question video quiz to see how much you already know about photosynthesis. Write your answers down in your science notebook. At the end of this unit you'll take the test again to show yourself how much you've learned!
NEXT


HOME
MONARCHS! PART I
PHOTOSYNTHESIS
FOOD WEBS
MONARCHS! PART II
TEACHER'S LOUNGE
TEACHER'S CORNER
RESEARCHER'S LOUNGE
Welcome to Food Webs
IMAGE
OF
FOOD WEB
FOOD CHAIN: A SERIES IN WHICH EACH ORGANISM USES THE NEXT LOWER MEMBER OF THE SERIES AS A FOOD SOURCE
- Merriam-Webster
OK, we know that plants make their own food. We also know that they use most of it for their own life processes. But what about the rest? Where does the excess energy go?
In the last section you learned about photosynthesis, the process by which plants make their own food. Plants and a few other photosynthetic organisms are the foundation of most food chains and food webs. In this section you will explore the way that energy flows from organism to organism.
Before you start this topic, take this 10-question interactive quiz to see how much you already know about photosynthesis. At the end of this section you'll take the test again to show yourself how much you've learned!
NEXT


Costa Rica: Rainforest Interactions
IMAGE OF COSTA RICAN FLAG & MAP
parenthood.com
IMAGE OF RAINFOREST
IMAGE OF HOWLER MONKEYS
IMAGE OF WATERFALL
Welcome to the rainforest! This vital ecosystem contains over half of the world's biodiversity, and is a great way to explore the interrelationships among organisms.
You have examined food chains, food webs and energy pyramids in class. Now is the time to apply that knowledge to a new environment.
For the remainder of this section you will carry out a variety of tasks in a project called Rainforest Interactions.
Have fun!
BACK
Go to the rainforest


HOME MONARCHS! PART I PHOTOSYNTHESIS
FOOD WEBS MONARCHS! PART II
TEACHER'S LOUNGE TEACHER'S CORNER
RESEARCHER'S LOUNGE
Welcome to Monarchs! Part I
IMAGE
OF
MONARCH BUTTERFLY
Before we talk about these magnificent creatures, you will do some classroom activities for this section - but there are some great videos to visit at Journey North...just go to the next page!
NEXT

HOME MONARCHS! PART I PHOTOSYNTHESIS
FOOD WEBS MONARCHS! PART II
TEACHER'S LOUNGE TEACHER'S CORNER
RESEARCHER'S LOUNGE

Welcome to Monarchs! Part II

IMAGE

OF

MONARCH BUTTERFLY

Now that you know about photosynthesis and food webs, let's see if we can apply these concepts to our Monarch population.

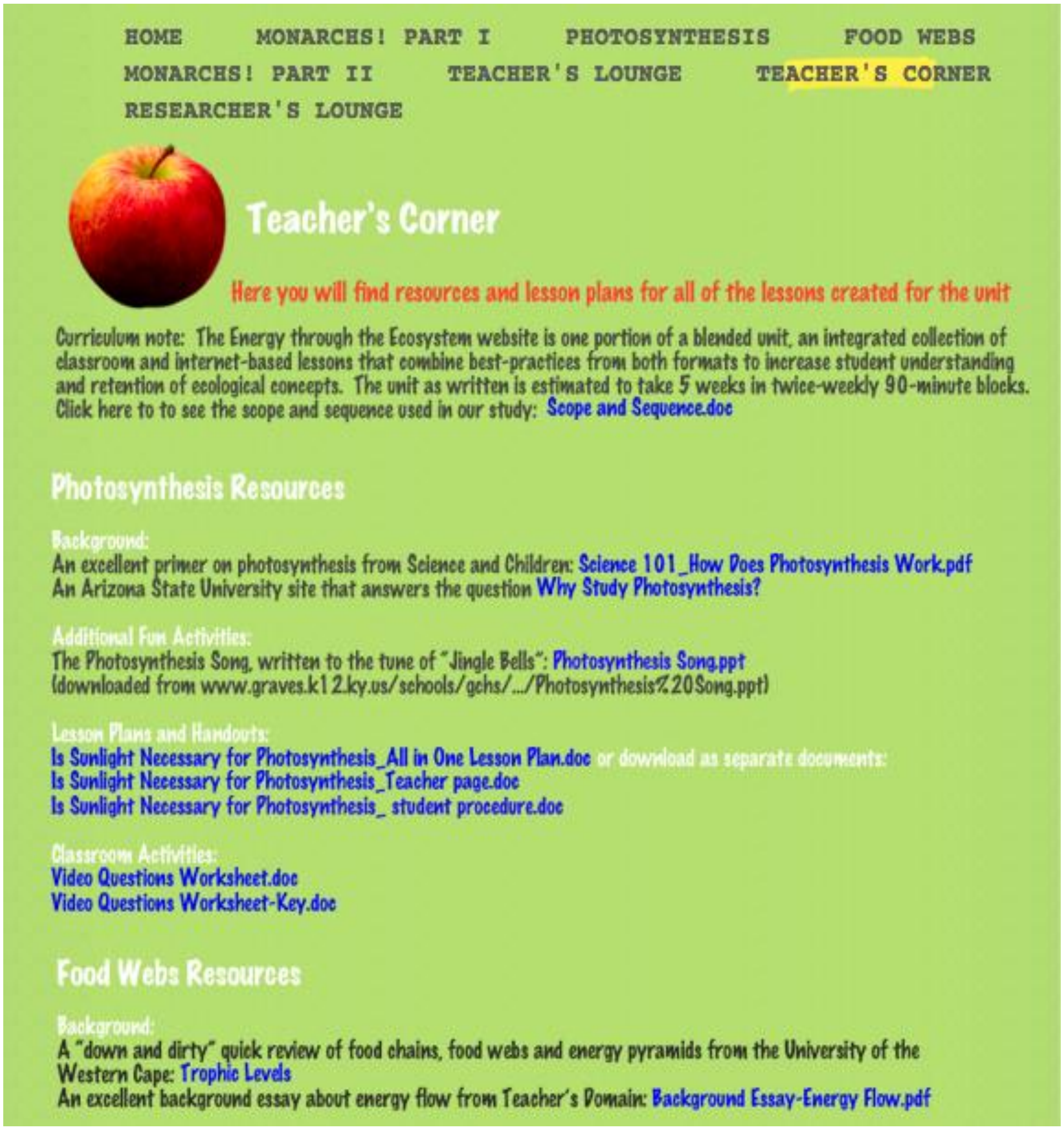
What does photosynthesis have to do with Monarchs?

Well, Monarchs get their energy from plants. Caterpillars eat leaves (lots and lots of leaves!). Leaves are the structures where photosynthesis takes place in most plants. And butterflies eat nectar from the flowers on plants. Nectar is sweet. Guess why? Because it has glucose, which is the main product of photosynthesis. Cool, huh? So without photosynthesis there would be no food for our Monarchs. (And of course, without photosynthesis there would be no oxygen, so there would be no animal life, but that's a different lesson...)

Where do Monarchs fit into a food web? A challenge for you!

A challenge question! Can you make a Monarch food web?

Take out a piece of paper and try to make a food web with at least 10 organisms. Need help? Print out Gulliver's Story - An Exercise in Active Reading.doc that you read in class - there's lots of good info there!



HOME MONARCHS! PART I PHOTOSYNTHESIS FOOD WEBS
MONARCHS! PART II TEACHER'S LOUNGE TEACHER'S CORNER
RESEARCHER'S LOUNGE

Teacher's Corner

Here you will find resources and lesson plans for all of the lessons created for the unit

Curriculum note: The Energy through the Ecosystem website is one portion of a blended unit, an integrated collection of classroom and internet-based lessons that combine best-practices from both formats to increase student understanding and retention of ecological concepts. The unit as written is estimated to take 5 weeks in twice-weekly 90-minute blocks. Click here to to see the scope and sequence used in our study: Scope and Sequence.doc

Photosynthesis Resources

Background:
An excellent primer on photosynthesis from Science and Children: Science 101_How Does Photosynthesis Work.pdf
An Arizona State University site that answers the question Why Study Photosynthesis?

Additional Fun Activities:
The Photosynthesis Song, written to the tune of "Jingle Bells": Photosynthesis Song.ppt
(downloaded from www.graves.k12.ky.us/schools/gchs/.../Photosynthesis%20Song.ppt)

Lesson Plans and Handouts:
Is Sunlight Necessary for Photosynthesis_All in One Lesson Plan.doc or download as separate documents:
Is Sunlight Necessary for Photosynthesis_Teacher page.doc
Is Sunlight Necessary for Photosynthesis_ student procedure.doc

Classroom Activities:
Video Questions Worksheet.doc
Video Questions Worksheet-Key.doc

Food Webs Resources

Background:
A "down and dirty" quick review of food chains, food webs and energy pyramids from the University of the Western Cape: Trophic Levels
An excellent background essay about energy flow from Teacher's Domain: Background Essay-Energy Flow.pdf

Lesson Plans and Handouts/Classroom Activities:
Intro to the Flow of Energy-Lesson Plan.doc
Marine Food Chain overhead.doc
Simple Food Chain overhead.doc
Deciduous Food Web overhead.doc
Water Energy Pyramid overhead.doc
Land Energy Pyramid overhead.doc
Food Chains and Food Webs handout.pdf
Coloring Energy Pyramid.doc
Food Chain Checkers.pdf
WISE-Food Chain Game instructions.doc
WISE-Get to know your animal worksheet.doc

Monarchs! Resources

Background:
An engaging primer by the San Diego Natural History Museum: Monarca: Butterfly Beyond Boundaries
An excellent, comprehensive site: Monarch Watch

Lesson Plans and Handouts:
Create a Monarch Waystation_All in One Lesson Plan.doc or download as separate documents:
Create a Monarch Waystation Lesson Plan.doc
Create a Monarch Waystation.doc
Monarch Life Cycle overhead.doc
Coloring Monarch Life Cycle-simple pic.doc
Coloring Monarch Life Cycle-complex pic.doc
Monarch Life Cycle handout.doc

Classroom Activities:
Gulliver's Story - An Exercise in Active Reading.doc

Mini-Activities:
Coloring Monarchs.doc from The Butterfly Site
Monarch Maze.doc from The Butterfly Site
Butterfly Maze from The Butterfly Site
Butterfly Word Search
Butterfly Book Marks (choose from 5)

Decomposition Columns Resources

Background:
An information primer on soil biology by the USDA's Natural Resource Conservation Service: The Soil Food Web
Background reading for decomposition columns from Bottle Biology: Microbiology of Decomposition

Lesson Plans and Handouts/Classroom Activities:
Build a Decomposition Column Lesson Plan.doc
Build a Decomposition Column.doc
Soil Food Web overhead.doc

Energy Flow through the Ecosystem **Scope and Sequence**

Tuesday			Thursday		
	Class Activities	Online Activities		Class Activities	Online Activities
8/25/09	1. "Create a Monarch Waystation" 2. Reflective journal (whole class)	N/A	8/27/09	1. "Is Sunlight Necessary for Photosynthesis?" 2. "Build a Decomposition Column" 3. Reflective journal (whole class)	N/A
9/1/09	1. Unit Pretest (whole class) 2. Gulliver's Story Part I 3. Reflective journal (whole class)	← "Photosynthesis" ←	9/3/09	1. Observations: Plants 2. Observations: Columns 3. Monarch mini-activity 4. Reflective journal (whole class)	"Photosynthesis" ←
9/8/09	1. Gulliver's Story Part II 2. Reflective journal (whole class)	"Photosynthesis" ←	9/10/09	1. Observations: Plants 2. Observations: Columns 3. Photosynthesis Culminating Activity (whole class) 4. Reflective journal (whole class)	Catch-up time ← ←
9/15/09	ITBS Testing pm: Science Blast?	N/A	9/17/09	ITBS Testing pm: 1. Observations: Columns 2. Science Blast?	N/A

9/22/09	ITBS Testing pm: Science Blast?	N/A	9/24/09	ITBS Testing pm: 1. Observations: Columns 2. Science Blast?	N/A
9/29/09	1. Intro to the Flow of Energy (whole class) 2. Monarchs Coloring handout 3. Reflective journal (whole class)	← "Food Webs" ←	10/1/09	1. Observations: Columns 2. "Food Chain Checkers" 3. Reflective journal (whole class)	"Food Webs" ←
10/6/09	1. Food Chain Game 2. Reflective journal (whole class)	Food Webs	10/8/09	1. Observations: Columns 2. Gulliver's Story Part III 3. Reflective journal (whole class)	Food Webs
10/13/09	1. Gulliver's Story Part IV 2. Monarch mini-activity 3. Reflective journal (whole class)	Food Webs ←	10/15/09	1. Observations: Columns 2. Unit Posttest (whole class)	Food Webs ←

Key:

Orange = Monarch section
Green = Photosynthesis section
Brown = Decomposition section
Pink = Food Webs section

← = No computer – whole class activity

Is Sunlight Necessary for Photosynthesis?
Teacher Lesson Plan

Introduction:

One student misconception about photosynthesis is that heat (rather than light energy) from the sun is a necessary component of the photosynthetic process. As students see plants grow, bloom and set fruit in the spring and summer, then "die" in the winter, it is not surprising that they would associate the warmth of the sun with photosynthesis. The goal of this lesson is to allow students to reframe their perceptions by preparing and observing plants in which they have masked portions of the leaves to block sunlight.

Over the course of two weeks students will try to determine if sunlight is necessary for photosynthesis by masking parts of leaves on four plants (two additional plants are used as controls). After one week (day 8) students will unmask two of the four experimental plants and make observations; after week two (day 15) all the plants will be unmasked. On this final day all six plants will be compared. The two control plants should remain unchanged. The two experimental plants unmasked on day 8 should now look "normal." The remaining two plants, which have just been unmasked, should have pale patches.

Time: Day 1: 40 minutes
Day 8: 30 minutes
Day 15: 45-60 minutes

Learning Goal:

Students know that light energy (rather than heat from the sun) is necessary for photosynthesis.

Learning Objectives:

1. Students will be able to identify a single independent variable in a scientific investigation and explain how the variable can be used to collect data and answer questions about the results of the experiment.
2. Students will be able to predict the relationship between sunlight and photosynthesis.
3. Students will be able to make accurate quantitative observations and record data.
4. Students will be able to infer and draw conclusions from scientific evidence and indicate whether further information is necessary to support a specific conclusion.

Vocabulary:

Photosynthesis
Chlorophyll
Light energy

Materials:

- 6 green, potted plants with healthy leaves (4 experimental, 2 control)
- Aluminum foil and/or brown paper bags (other solid materials may be substituted)
- Scissors
- Paper clips
- Sticky labels or paper and tape to label each pot #1-6
- Copies of Is Sunlight Necessary for Photosynthesis Student Procedure
- Student Science Journals

Description:

Note: The original lesson plan has been modified from eight to fifteen days to accommodate a twice-weekly science block. Using this longer *interval should actually result in stronger visual evidence for photosynthesis.*

This activity is designed to engage students in photosynthesis and support online learning experiences. No initial direct instruction is necessary; rather, let students observe and draw their own conclusions.

Concluding lesson:

At the end of the photosynthesis section revisit this lesson and ensure that students have made the connection between the action of photosynthesis and the changes in leaf appearance over time.

Show or assign the following students to view the videos of photomorphogenesis (the process by which plant development is controlled by light) offered by Indiana University: http://plantsinmotion.bio.indiana.edu/plantmotion/earlygrowth/photomorph/photomorph.html

Name: ________________________ Date: ____________________

Is Sunlight Necessary for Photosynthesis? Student Procedure

Procedure for students:

You will have six plants: four of them will be used in the experiment, and the other two will be used as control plants. Label the pots #1-6 (label the control pots #5 and #6).

The following instructions are for the four experimental plants ONLY:

1. Look at your plants. How many leaves does each plant have? How big are the leaves? For this activity, you will want to cover part of 2-3 leaves per plant; but no more than ½ of the total number of leaves should be covered. Use this chart:

Plant 1, #leaves = __________

Plant 2, #leaves = __________

Plant 3, #leaves = __________

Plant 4, #leaves = __________

Total # leaves = __________

2-3 leaves per plants OR ½ of total # leaves = _______
(this is how many shapes you will cut out in step #2)

2. Cut out a variety of shapes (circles, squares, triangles, stars, etc.), from the aluminum foil or paper bag, each large enough to cover ½ leaf.
3. Fasten the shapes to individual leaves with paper clips (any part of the upper leaf is ok).

The following instructions are for all 6 plants:

4. Using your lab journal, draw the six plants as they look now.
   a. Describe what shapes are on each plant and where they are placed.
   b. Quietly make a prediction: what do you think is going to happen to the leaf parts that are covered? Don't share your thoughts yet! Just write down what *you* think.
   c. Now talk to your lab partner or neighbor. What does he or she predict? How is that similar to or different from your prediction?
   d. You and your partner/neighbor should talk to at least one other group and share your predictions. How are they similar? How are they different?

      Note: This is part of the "thinking out loud" process that scientists use. Do not worry about being right or wrong! Just think it through. At the end of the lesson, you will know whether your prediction was correct.

5. Find a window with plenty of sunlight during the day. Place all 6 plants in that location and water them evenly (try to give all the plants about the same amount of water, but it is not necessary to measure the volume).
6. Leave the plants alone for 7 days, except to water as needed.

On day 8, remove the shapes from two of the plants (you may move the plants to a table for easy viewing).

7. Compare the area of each leaf that has been uncovered to the rest of that leaf. In your journal, draw your observations. Note: Be sure to write down which plants have been uncovered! *After* you write down your thoughts, discuss your observations with a partner/neighbor, then another group as you did in step 4.
8. Return the plants, still uncovered, to the window. You will let all the plants sit for the next 7 days.

On day 15, move all of the plants to a table for easy viewing.

9. Compare the plants that were uncovered on day 7 to the control plants. What do you see? Quietly record your observations in your journal. Don't share your thoughts yet!
10. Now remove the shapes from the remaining two plants. Compare these plants to the control plants *and* the plants you uncovered on day four. Record these observations in your journal. Ask yourself these questions:
    a. What do you think happened?
    b. Do your observations support or refute your prediction from day one?
11. Write down your thoughts.
12. Compare your conclusion to your partner's/neighbor's. How are they similar? How are they different? This time, try to reach a consensus (an agreement) about what happened before you talk to another group.
13. Have a class discussion: each team should explain its conclusion along with supporting evidence (example: we think _________happened because we saw _________ and that means______).

Introduction to the Flow of Energy (Food Webs)
Teacher Lesson Plan

Introduction:
In ecology, energy flow (calorific flow) refers to the flow of energy through a food web. The simplest representation of energy flow is a food chain. A food web, or collection of interacting food chains, is a more realistic representation of the way energy actually flows through the ecosystem. An energy pyramid is a different representation of the energy flow that emphasizes the decreasing amount of available energy at each trophic level.

Teacher's Domain[3]*:*
Energy flows through ecosystems. Plants collect the sun's energy with their leaves and use it to transform water and carbon dioxide into high-energy carbohydrate molecules. When an animal consumes these molecules (such as when a herbivore like a rabbit eats a carrot), the stored energy is released and helps to fuel the animal's cellular activities, including the production of new molecules, cells, and tissues. If a carnivore then consumes the herbivore (for example, if a wolf eats the rabbit), the carnivore will in turn be fueled by the energy stored in the herbivore's tissues. In this way the solar energy originally collected by plants is transferred from one organism to another.

Learning Goals[4]**:**

- *Students know* matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.
- *Students know* producers and consumers (herbivores, carnivores, omnivores, and decomposers) are related in food chains and food webs and may compete with each other for resources in an ecosystem.

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[3] http://www.teachersdomain.org/resource/tdc02.sci.life.oate.energyflow/ Retrieved 16 August 2009

[4] California Science Standards

Learning Objectives[5]:
Students will be able to:

- Explain food chains and food webs and identify producers and consumers in an ecosystem
- Classify organisms according to characteristics that are similar and different

Vocabulary:

Food chain
Food web
Energy pyramid
Trophic level

Materials:

Overheads:
Simple Food Chain
Marine Food Chain
Deciduous Food Web
Land Energy Pyramid
Water Energy Pyramid

Handouts:
Food Chains and Food Webs
Coloring Energy Pyramid

Preparation:
Make overhead transparencies
Make copies of student handouts

Description:
This is an introductory mini-lesson to acquaint students with energy flow through food chains, food webs and energy pyramids before they begin the online "energy flow" section of the ecology unit. As the students will

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[5] NAD Key Learnings

have ample time to explore and create food chains and food webs, a short explicit instruction regarding standard representations should suffice. For instance, an arrow always points toward the energy flow as shown below:

Sun → plant → grasshopper → mouse → owl

This representation is shorthand for the following:

"The sun gives energy to the plant; the plants gives energy to the grasshopper, the grasshopper gives energy to the mouse; the mouse gives energy to the owl."

Note: Each organism represented in a food chain or food web represents a population of those organisms; in the chain above, the plant, grasshopper, mouse and owl each represent populations of those types of organisms.

An energy pyramid shows that the amount of available energy decreases as it travels up the food chain/pyramid. Approximately 90% of the energy an organism consumes is used in its life processes, leaving only 10% available for the next consumer. In an introduction such as this, perhaps the most important message for students to understand is that the pyramid shows that each trophic (feeding) level supports fewer organisms than the one below it.

Misconception Alert!

A common misconception regarding food webs is that a change (increase or decrease) in the numbers of one type of organism will only affect other organisms in the immediate food chain. When looking at a food web, students often do not recognize that there are indirect effects on other organisms, or that organisms "far away" in the food web will still be affected by the change.

Take home message: A change in one type of organism affects every other type of organism in the food web!

Concluding lesson:

The online project does not adequately connect food chains/webs and energy pyramids. Students will benefit from revisiting energy pyramids after they have completed the project.

Prior Prep Needed Teacher Lesson Plan

Build a Decomposition Column Lesson Plan

Introduction:

From Bottle Biology[6]: You can think of the Decomposition Column as a miniature compost pile or landfill, or as leaf litter on a forest floor. Through the sides of the bottle you can observe different substances decompose and explore how moisture, air, temperature and light affect the process.

Decomposition involves a whole community of large and small organisms that serve as food for each other, clean up each other's debris, control each other's populations and convert materials to forms that others can use. The bacteria and fungi that initiate the recycling process, for example, become food for other microbes, earthworms, snails, slugs, flies, beetles and mites, all of which in turn feed larger insects and birds.

Time: Day 1: 50 minutes
Weekly Observations: 15-20 minutes

Learning Goal[7]:

Students know decomposers, including many fungi, insects, and microorganisms, recycle matter from dead plants and animals.

Learning Objectives[8]:

Students will be able to:

- Identify various ecosystems (grasslands, forests, wetlands, desert, etc.) and the organisms that live there
- Understand God made living things to grow and change

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[6] www.bottlebiology.org/investigations/decomp_main.html Retrieved 15 August 2009
[7] California Science Standards
[8] NAD Key Learnings

• Make observations
• Ask questions or form hypotheses based on these observations
• Plan a simple investigation
• Collect data from the investigation
• Use the data collected from the investigation to explain the results
• Safely use and store tools and equipment

Vocabulary:
Decomposers
Ecosystem
Biotic

Materials: (per group of 2-3 students)

- Three 2-liter soda bottles
- One bottle cap
- Chunky peanut butter <u>(only if no one has allergies!)</u> to clean glue from bottles (optional)
- Box top
- Utility knife (teacher only)
- Scissors
- Marking pen or crayon
- Waterproof or binding tape
- Leaves
- Twigs
- Grass and plant clippings
- Kitchen scraps
- Newspapers
- Soil
- Other materials if desired
- Science journals

Handouts:
Bottle Basics
Build a Decomposition Investigation Column

Preparation:

Ahead of time: Ask students to bring in 3 2-liter bottles per group (plus extras to have on hand) or purchase bottles from a discount store.

Collect materials
Make copies of handouts

Description:

During this science unit students will be studying the flow of energy through the biotic (living) portion of an ecosystem. When a living thing dies, the energy it has consumed dissipates; however, nutrients are conserved as its' remains are broken down by organisms in the soil known as decomposers. Eventually, some of the nutrients will be returned to the surface food web.

Today students will build their decomposition columns. Over the next few weeks, they will begin to see the materials break down in their columns; they will notice many changes in the look and the smell of the column as different organisms use the nutrients available to them and in turn become food for other organisms. Students should make some observations in their science journals each week until you determine that the study is over.

Note: Decomposition columns can contain strong odors; avoiding meat and dairy scraps will result in less pungent odors. Students are directed in their lesson to place a layer of soil on top of the material; this will also assist with odor containment. Adding fruit may result in the appearance of fruit flies. Use small holes to keep the fruit flies inside the columns. You may also choose to place the columns outside to mitigate these normal, but potentially "icky" processes.

Concluding lesson:

As decomposition occurs over an extended period of time, this lesson will be concluded after the remainder of the life energy unit is complete.

This is a good opportunity to revisit the concepts of the unit and ensure that students have retained the "big ideas," as well as keep the Monarch thread active for spring lessons.

Resources/Credits: This lesson was inspired by the "Decomposition Investigation Column" lesson by Bottle Biology, and created to incorporate all of the components of our learning unit (see the Scope and Sequence for more information).

Build a Decomposition Column

Introduction

During this unit you will be studying the flow of energy through the biotic (living) portion of an ecosystem. When a living thing dies the energy flow continues as its' remains are broken down by organisms in the soil known as decomposers. Eventually some of the energy will be returned to the food chain as described below.

From Bottle Biology[9]:
Decomposition involves a whole community of large and small organisms that serve as food for each other, clean up each other's debris, control each other's populations and convert materials to forms that others can use. The bacteria and fungi that initiate the recycling process, for example, become food for other microbes, earthworms, snails, slugs, flies, beetles and mites, all of which in turn feed larger insects and birds.

You can think of the Decomposition Column as a miniature compost pile or landfill, or as leaf litter on a forest floor. Through the sides of the bottle you can observe different substances decompose and explore how moisture, air, temperature and light affect the process.

Today you will build your decomposition column. Over the next few weeks, you will begin to see the materials break down in your column. You will notice many changes in the look and the smell of the column as different organisms use the nutrients available to them and then become food for other organisms. Make some observations in your science journal each week until your teacher tells you that the study is over.

Materials (per group of 2-3 students)

- Three 2-liter soda bottles
- One bottle cap
- Chunky peanut butter <u>(only if no one has allergies!)</u>
- Box top
- Utility knife (teacher only)

[9] www.bottlebiology.org/investigations/decomp_main.html Retrieved 15 August 2009

- Scissors
- Marking pen or crayon
- Waterproof or binding tape
- Leaves
- Twigs
- Grass and plant clippings
- Kitchen scraps
- Newspapers
- Soil
- Other materials if desired
- Science journals

Handouts:
Bottle Basics
Build a Decomposition Investigation Column

What To Do:

1. Prepare your bottles
   a. Remove all labels from your bottles.
   b. Rub a small amount of peanut butter on remaining glue if labels do not come off cleanly.
   c. Check your bottles – they must be clean and dry before you start marking them.

2. Cut your bottles
   a. Mark your bottles with a marker or crayon.
   b. Place a bottle in the box top.
   c. STOP! Your teacher must inspect your bottle before you cut. She will start the cuts for you with a utility knife.
   d. Cut the bottle according to the "Build a Decomposition Investigation Column" handout.
   e. Repeat this process with the other two bottles.

3. Build and fill your column
   a. Begin joining the pieces according to the "Build…" handout.
   b. Make some "stars" of holes in the side to aid in air exchange.

c. Make a "tossed salad" using the organic materials above.
d. Fill your column about halfway with the material (twigs can stick above).
e. Layer a bit more soil on top of your mixture to help control odors.
f. Dampen the soil to promote decomposition
g. Finish joining the pieces to complete your column.

4. Make observations and monitor changes

You will be taking observations weekly to see how the pile is decomposing and what types of organisms are active.

a. Make a baseline observation now.
   - In your science journal note the color, texture, smell and shape of the pile.
   - Try drawing what you see.
   - What do you predict will happen during decomposition?

b. Take the same observations each week.
   - Again note the color, texture, smell and shape of the pile.
   - Look for changes: Is it getting taller or shorter? Is the bottle warm to the touch?
   - Look for the appearance of any "critters," such as flies, beetles, slugs, millipedes, or snails.
   - Do your observations support your prediction? If not, make a new prediction.

c. Continue with weekly observations until your teacher tells you the study is over.

Most importantly, have fun doing science!

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APPENDIX B

Blended Unit Study Informed Consent-Teacher

Dear Teacher,

My name is Mikki Westbie. I am a certificated science and math teacher completing a Master's degree in Science Teaching at California State University, Chico. My culminating activity is to create and test a four- to six-week science learning unit, composed of web-based and hands-on classroom activities.

My goals for this project are:

- Support the special curricular needs of a rural, multiple grade/multiple subjects teacher by designing a science unit using accepted best practices.
- Determine whether this learning modality is as beneficial to the teacher and student as is the existing curriculum.

To meet these research goals, I will be attempting to answer several questions:
As compared to the existing curriculum:

- What effect(s) does the blended unit have on the teacher's perceptions about teaching science?
- How and why does the blended unit benefit a teacher's life science curriculum?
- What effect(s) does the blended unit have on student perceptions about learning science?
- To what extent does the blended unit teach students the targeted standards?

I expect to collect research data from the following sources:

- Pre- and post-unit surveys.
- Teacher evaluation of materials.
- Reflective learning journal.
- Participant and nonparticipant observations.
- Telephone and in-person interviews and casual conversation.

All documents will be maintained with strict confidentiality.

In addition to keeping a personal notebook, I may audiotape our interviews to aid in further data recall; audio tape(s) will be kept in a locked filing cabinet and destroyed one year after the end of the study. You and I may use Skype technology to complete virtual classroom observations; these sessions will not be videotaped to ensure participants' anonymity. All data recordings will be maintained with strict confidentiality.

Risks and Benefits:

There are no anticipated risks to participation in this study. In addition to any benefit you may receive by using the proffered curriculum, some of the benefits of participating are that results of the study may help other teachers integrate web-based and hands-on learning in blended science units to create meaningful learning experiences. In addition, the results may contribute to our understanding of how blended learning units affect the way people learn.

I.,_____________________________ affirm that I have read and understand the above statement, have had all of my questions answered, and have been given a blank copy of this consent form for my records.

Teacher Signature:___________________________ Date:_______________________

Please check below. You may change your selection at any time:

_______ Yes, I wish to participate in this research.

_______ No, I do not wish to participate in this research.

Blended Unit Study Informed Consent-Parent/Guardian

Dear Parent/Guardian,

My name is Mikki Westbie. I am a certificated science and math teacher completing a Master's degree in Science Teaching at California State University, Chico. My culminating activity is to create and test a four- to six-week science learning unit, composed of web-based and hands-on classroom activities.

My goals for this project are:

- Support the special curricular needs of a rural, multiple grade/multiple subjects teacher by designing a science unit using accepted best practices.
- Determine whether this learning modality is as beneficial to the teacher and student as is the existing curriculum.

To meet these research goals, I will be attempting to answer several questions:

As compared to the existing curriculum:

- What effect(s) does the blended unit have on the teacher's perceptions about teaching science?
- How and why does the blended unit benefit a teacher's life science curriculum?
- What effect(s) does the blended unit have on student perceptions about learning science?
- To what extent does the blended unit teach students the targeted standards?

There are several components to this research, most of which will be conducted with your child's classroom teacher. However, student feedback is critical to the successful creation of meaningful learning experiences, and I would like to offer your student the opportunity to participate in the research study. Participation is voluntary; the decision to participate or not will not affect your student’s grade for this unit. Students who do not participate will be given an alternate activity (such as silent reading or another quiet activity) during the research activities described below. All responses will be kept confidential; that is, responses will be identifiable by the researcher (Mikki Westbie) but your student's identity will not be revealed to anyone else. The study site and participants will be masked to ensure anonymity.

I expect to collect research data from the following sources:

- Pre- and post-concept tests for the individual learning modules and overall science unit. The tests are standards-based and will allow me to measure changes in students’ understanding of the targeted scientific concepts. The tests are not graded, and will be coded to mask student identities.

- Reflective learning journals. This will help me establish trends in student perceptions about the activities completed and determine where changes may be needed for future units. The journals are not graded, and will be coded to mask student identities.
- Group interviews and informal individual queries regarding various learning experiences before, during and after the course of the unit. Responses and identities will be kept confidential.

In addition to keeping a personal notebook, I may audiotape group discussions to aid in further data recall; audio tape(s) will be kept in a locked filing cabinet and destroyed one year after the end of the study. The teacher and I may use Skype technology to complete virtual classroom observations; these sessions will not be videotaped. With all forms of data recording, students' responses will be identifiable only by myself; identities will be kept confidential.

Risks and Benefits:

There are no anticipated risks to participation in this study. Some of the benefits of participating are that results of the study may help other teachers integrate web-based and hands-on learning in blended science units to create meaningful learning experiences. In addition, the results may contribute to our understanding of how blended learning units affect the way people learn.

I.,______________________________ affirmed that I have read and understand the above statement, have had all of my questions answered, and have been given a blank copy of this consent form for my records.

Parent/Guardian Signature:_________________________ Date:________________________

Name of student:_____________________________________

Please check below. You may change your selection at any time:

_________I give permission for my child to choose whether or not to participate in this research.

_________I do not give permission for my child to participate in this research.

Blended Unit Study Informed Consent-Student

<u>Script</u>

The teacher will read this out loud: Hi everyone. My name is Mikki Westbie. I am a teacher working on a research project so that I can graduate from Chico State with a special degree in science teaching. Your teacher and I will be doing some research on a science unit I have created. I would like your help, too. While you learn about photosynthesis, food webs, and other life science topics in this unit, I would like to collect some information from you about what you have learned and what your thoughts are about the lessons I have made.

You **do** have to complete the unit just like other school work, your teacher gives you. You **do not** have to help me with my research. Nothing good or bad will happen to you by helping me collect information. Your grade for this unit will not be affected by whether or not you participate. Only your lessons will be graded, just like all your other schoolwork. If you do not choose to participate, your teacher will give you an alternate assignment for the time that others are collecting and recording information. If you do participate, you will have a code name so that nobody but you, your teacher, and me will know which work is yours.

If you decide to participate, here is what you will do: you will complete a pre-test before the unit to see what you know about the things you will be studying. After the end of the unit, you will complete the test again to see what you have learned. This test is not graded. After each lesson, you will write in a journal about what you have learned, what you liked and did not like, and how *you* would teach the lesson to make it better. I will also ask you some questions in a group so that you can tell me your likes and dislikes, as well as share other ideas which you feel would make your science learning easier and better.

Do you have any questions?

Please check below. You may change your selection at any time:

_______ Yes, I wish to participate in this research.

_______ No, I do not wish to participate in this research.

Name:____

Date:____

Prompts for Teacher Reflective Journal

Directions: Please use the following prompts to help you evaluate this lesson. Feel free to add additional comments!

Date:

Lesson Taught:

What percent of the time were most students engaged during today's activity?

More than 90%   70-90%   50-70%   30-50%   Less than 30%

Comments:____

____

____

When student were engaged, how engaged were they?

Very Engaged	Engaged	Somewhat Engaged	Not Very Engaged	Not at All Engaged

Comments:____

____

____

Did the lesson adequately scaffold the targeted concept(s)? Please explain.

Was the lesson meaningful? Please explain.

Did you feel adequately prepared to teach this lesson (does this lesson need more teacher background material)?

<u>Overall impressions</u>

- What worked in this lesson?
- What did not work in this lesson?
- How would you modify the lesson for next time?
- Other questions, comments, concerns, suggestions?

Prompts for Student Reflective Journal

Directions: Please answer each question completely and honestly. Remember, you are helping to make this a better unit!

What I did today: ___________________________________

1. What I learned today:

2. What I liked (what was good) about this lesson:

3. What I did not like (what could be better) about this lesson:

4. If *I* were the teacher, *I* would teach the lesson *like this*:

5. Other things I would like to share:

Science Pre-/Post-test

Date: ______________________ Code name: ___________________________

Circle the correct answer:

1. An organism that feeds primarily on the bodies of dead animals is a(n):
   A. producer B. consumer C. decomposer D. composer

2. A group of organisms of a single species that inhabit a certain region at a particular time (such as a group of students) is a(n):
   A. community B. ecosystem C. population D. species

3. All of the living and nonliving things with which an organism may interact is called:
   A. ecosystem B. environment
   C. population D. temperature

4. California State Released Test Question (2003-2008; Grade 5) item #31, pertaining to gases used in photosynthesis (www.cde.ca.gov/ta/tg/sr/css05rtq.asp)

5. A Monarch butterfly is an example of:
   A. decomposer B. omnivore C. carnivore D. herbivore

Massachusetts Comprehensive Assessment System Test Question (2008; Grade 5) item # 17 pertaining to removal of decomposers from the ecosystem (http://www.doe.mass.edu/mcas/2008/release)

7. The arrow in a food chain means:
   A. "eats" B. "hunts" C. "gives energy to" D. "plays with"

California State Released Test Question (2003-2008; Grade 5) item #35 pertaining to a simple food web (www.cde.ca.gov/ta/tg/sr/css05rtq.asp)

Massachusetts Comprehensive Assessment System Test Question (2008; Grade 5) item # 21 pertaining to the way plants use energy received by sunlight (http://www.doe.mass.edu/mcas/2008/release)

10. Another name for a plant eater is:

A. an herbivore

B. a primary consumer

C. both A and B

D. neither A nor B

California State Released Test Question (2003-2008; Grade 5) item #36 pertaining to a simple food web (www.cde.ca.gov/ta/tg/sr/css05rtq.asp)

12. Another name for the organism that eats an herbivore is the:

A. secondary consumer
B. primary consumer
C. producer
D. decomposer

13. Each level in a food pyramid is called a:

A. consumer level
B. trophic level
C. production level
D. eating level

14. Examples of decomposers are:

A. bacteria
B. fungi
C. both A and B
D. neither A nor B

15. The organism that is never included in a food chain is a(n):

A. decomposer
B. herbivore
C. producer
D. carnivore

16. A network of interrelated food chains is:

A. another food chain
B. a food web
C. an ecosystem
D. an environment

17. A student planted the same kinds of seeds in pots *A* and *B*. She planted five seeds in pot *A* and five seeds in pot *B*. The amount and type of soil in both pots was the same. She added the same amount of water to both pots each week. Pot *A* was placed on a sunny windowsill. Pot *B* was placed in a dark room. After four weeks, she observed the plants in both pots. The plants in pot *A* were green, with short, thick stems. The plants in pot *B* were yellow, with tall, thin stems.

Why is the plant in pot B taller than the plant in pot A?

18. Draw a small food web for a Monarch butterfly. (Use 5-10 organisms)

Questions #4, 8, 11 from CST: Grade 5(2003-2008) at http://www.cde.ca.gov/ta/tg/sr/css05rtq.asp
Questions #6, 9 from MCAS: Grade 5 (2008) at http://www.doe.mass.edu/mcas/2008/release/
Questions #7, 10, 12, 13, 14, 15, 16 modified from QSTN at http://qldscienceteachers.tripod.com /worksheets/biology/ecology/

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