Using Lesson Study to Increase Student Motivation to Read and Comprehend Science Texts

Maria R. Garling
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Using Lesson Study to Increase Student Motivation to Read and Comprehend Science Texts

Content area literacy has been of increased focused throughout the educational system. Educators are realizing that in order to increase students' awareness of the language and skills in their content area they need to focus on building literacy proficiency that is specific to their particular subject. Because literacy, and especially reading, is often such a resistant task for students to participate in, I chose to explore a method of increasing students' motivation to read. The problem in many classrooms is not only to motivate students to read but for students to understand the text they are reading. The literature points out that only a small fraction of the high school population has text decoding problems while a significant portion of the high school population has trouble comprehending text. Through motivating students by appealing to real world problems and hands on activities and employing reading strategies from the literature, hopefully a method will be discovered for increasing students' reading comprehension.

Lesson study, an action research strategy, will be used to assess and study the success of this methodology. This strategy is a teacher as researcher model that is employed frequently in Japan and has been modified for use in this study. The problem with lesson study is that many United States institutions do not feel that it is able to be modified for our country; that it is too embedded in Japanese culture.

This study will discuss the successful implementation of lesson study in the United States. In addition, this study will examine the outcome of implementing and refining the use of hands-on activities coupled with science expository texts to increase both motivation to read and reading comprehension.
Review of Literature

Content area literacy has been an area of increasing focus in education over the past 10 to 15 years. Although most educators will agree that there is a need to increase students' reading comprehension abilities, many feel that they are not equipped to aid students in that area (Surash, 2005). In fact, there is much debate in the literature on which methods are the most effective at promoting student reading comprehension. Educators also have mixed feelings about integrating reading strategies into their content areas because they are not aware of the relationships between reading and its ability to generate and strengthen content knowledge. Many educators feel that spending time teaching students content specific reading strategies detracts from time focused on content. The first section of this review focuses on content area literacy from a science perspective and includes discussions of the definitions and components involved in science content area literacy, why content area literacy is important to science education, whether or not reading the weaker area of content area literacy in science, and strategies for improving reading comprehension in science. The purpose and scope of this section will bring a new relevance to time spent reading science texts in the classroom.

In order to explore the inconsistency in the literature on the effectiveness of various reading strategies, a method of collaboration and classroom research, lesson study, will be reviewed. The process of lesson study is a method of teacher collaboration from Japan that has many distinct elements from that of United States' collaborative models. Because lesson study is from a different culture, implementation in the United States will have inherent problems unless modified for use in a dissimilar culture. The second half of the review will focus on lesson study and include a discussion of the
general information about the process and its emergence in the United States, a
comparison of lesson study with other collaborative models, and how to adapt and
measure the success of lesson study in the United States. The purpose of this review is to
identify lesson study as the predominate collaboration tool teachers could use to help
their students increase their content area literacy skills.

Definitions and Components of Science Content Area Literacy

The major avenues of literacy include reading, writing, speaking, and listening
(Thier, 2002). Reading is not simply decoding print but understanding, retaining, and
applying meanings within the text. Writing and speaking concisely and meaningfully are
a component of literacy. Listening to others to derive meaning is also another
component. Content area literacy is defined as the ability to use language to learn (Vacca
& Vacca, 1999; Biancarose & Snow, 2004; Thier, 2002). “Content literacy - the ability
to use reading and writing to learn subject matter in a given discipline - is a relatively
new concept that holds much potential for students’ acquisition of content” (Vacca &
Vacca, 1999, p. 8). This is the difference between the reading agenda of the primary
grades and secondary education; primary grades the focus is learning to read, secondary
is reading to learn (Jacobs, 2002; Biancarose & Snow, 2004). In content area literacy,
reading specifically has changed in meaning to include how students interact with text,
not coming to text as blank slates. Students bring prior knowledge with to the text and
their interaction with the verbiage on the page allows them to construct their new, distinct
meaning from the text (Roth, 1991; Padak & Davidson, 1991; Vacca & Vacca, 1999;
Abell, 1992; Heselden & Staples, 2002; Biancarose & Snow, 2004; Jacobs, 2002; Snow,
2002; Holloway, 2002; Barton, Heidema, & Jordan, 2002; D’Acangelo, 2002; Padilla,
Schema is how information is stored and organized in the brain and greatly impacts how students comprehend texts (Vacca & Vacca, 1999). Schema influences how readers make predictions and anticipate outcomes as well as fill in the gaps during reading. While students are reading, schema helps them organize the information in order to retain and remember it. This organization is also influenced by insight, judgment and evaluation that are processes mediated by schema. Understanding from text is hence a very personal process that is more than doing or knowing but is a problem solving endeavor mediated by specific regions of the brain (Jacobs, 2002; Snow, 2002; Padilla, Muth, & Lund-Padilla, 1991). Reading is one very powerful way students can make meaning of content and generate understanding. According to the National Center for Improving Student Learning and Achievement in Mathematics and Science (2005), understanding is a mental activity "that contributes to the development of understanding rather than as a static attribute of an individual's knowledge." (p. 1).

Students who are truly engaged in reading will know how to interact with the text and get what they need out of the reading. Increasing students' engagement with texts increases their confidence, competency, and decreases ambivalence regarding reading (Vacca & Vacca, 1999).

The term literacy has fluctuated to also describe the level of knowledge a person has about a particular topic in addition to their ability to read and write in that content area (Vacca & Vacca, 1999). In particular, this paper is concerned with increasing students' science literacy which Thier (2002) describes as the "possession of a set of skills that marries knowledge of science concepts, facts, and processes with the ability to use language to articulate and communicate about ideas" (p. 1). Although often times it
is said that math is the language of science, this is not the case (Lemke, 2004). It is a mix of components: math is used to interpret results, visual representations are used for abstract concepts, which are all embedded in rich language. Since science language is not the same as that studied by linguists, it needs a different context in which to be studied (Lemke, 2004; Wellington & Osborne, 2001). In particular, studies performed by Cassels and Johnstone (1985) found that not only do students have difficulty understanding scientific words imbedded in the language of science texts but also other descriptive words not necessarily specific to science such as: abundant, incident, complex, spontaneous, relevant, valid, random, composition, contrast also caused students comprehension problems (Wellington & Osborne, 2001). Pickersgill and Lock (1991) also found this same phenomenon with students in their study (Wellington & Osborne, 2001). Therefore, science educators have the challenge of assisting students in overcoming the difficulties of the unique blended language of science in order to become scientifically literate individuals.

What distinguishes a scientifically literate individual? According to Uno and Bybee (1994) there are four levels of scientific literacy (although they discuss biological literacy specifically): nominal, functional, structural, and multidimensional. In the nominal domain, students possess many misconceptions about scientific concepts; they can identify terms and attempt definitions but with limited experience. In the functional domain, students are still at the basic rote memorization level. The structural domain of literacy involves students being able to explain scientific phenomenon in their own words and are able to work well with the scientific method of inquiry. The multidimensional domain is the ability to interconnect many ideas in science and apply them to the
investigation of a scientific problem. Increasing students degree of scientific literacy through the use of text will allow students to demonstrate that they "know how to analyze and process data; know that some science-related problems in a social and personal context have more than one accepted answer" and know that social and personal problems are multidisciplinary, having political, judicial, ethical, and moral dimensions" (Yore, 2004, p. 84). More importantly, an increased level of scientific literacy allows students to be able to "distinguish experts from the uniformed, theory from dogma, data from myth and folklore, science from pseudoscience, evidence from propaganda, facts from fiction, sense from nonsense, and knowledge from opinion" (Yore, 2004, p. 83).

Most students will need to be able to synthesize science information from the media in their adult life. Learning how to read articles in magazines and newspapers, critically, as well as understanding the science behind the information presented is the job of science educators and therefore should be a priority (Wellington & Osborne, 2001; Heselden & Staples, 2002).

**Importance of Literacy to Science Education**

In 2002, only 36% of grade 12 students were performing at a proficient literacy level according to the National Association for Educational Progress; this percentage has declined from 40% in 1998 (Campbell & Kmiecik, 2004; Biancarose & Snow, 2004). To increase pressure on teachers, according to the No Child Left Behind (NCLB) act, students will be assessed in science during the 2007 school year (Lundstrom, 2005). Teachers feel that it may be the job of a reading specialist to teach skills related to literacy and that they need to focus their time on science content (Vacca & Vacca, 1999;
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Billmeyer & Barton, 1998). However, the teacher is really showing students how to use text and writing to construct content specific knowledge — to discover, clarify, and extend meaning (Vacca & Vacca, 1999). According to the National Center for Improving Student Learning and Achievement in Mathematics and Science (2005), understanding is a mental activity “that contributes to the development of understanding rather than as a static attribute of an individual’s knowledge” (p. 1). The agency identifies five mental activities that support scientific understanding: 1) constructing relationships; 2) extending and applying scientific knowledge; 3) reflecting about experiences; 4) articulating ideas; 5) making knowledge personal. When students are engaged in active reading processes and strategies they are performing all of these mental activities. “If spending time with texts helps students learn new concepts and think critically, then it makes sense to create time for engaged reading within content disciplines, where building knowledge and learning to reason are the priorities” (Ivey, 2002, p. 22). By integrating literacy skills into the content areas, teachers are creating readers who possess a broader understanding of content knowledge (Holloway, 2002; Topping & McManus, 2002). According to Thier (2002), “The stronger a student’s literacy skills, the stronger the student’s grasp of science will be” (p. 4).

As mentioned, science teachers may decrease the importance of content area literacy because they do not feel it is their responsibility to teach it. Bullock stated in 1975, “Since reading is a major strategy for learning in virtually every aspect of education... it is the responsibility of every teacher to develop it” (Wellington & Osborne, 2001). In general, reading in the content areas prepares students for basic adult literacy; especially how to approach a strange and unfamiliar text (Heselden & Staples.
2002). However, reading in science requires different strategies than in other content areas because of the unique features of science text (Biancarose & Snow, 2004; Gee, 2004). Therefore, it requires a science teacher to give students the skills necessary for dissecting science texts utilized by experts in the science field. Because language is the primary avenue that students must use to understand science, "a student’s achievement in science will be directly proportional to the student’s ability to use language" (Thier, 2002, p. 4). In addition, if students are to share an experience authentic to that of real scientists, there needs to be a greater balance in reading since scientists do spend a significant portion of their time reading journal articles for information amongst other literacy endeavors (El-Hindi, 2003; Heselden & Staples, 2002; Yore, 2004; Wellington & Osborne, 2001). In fact, reading is often the neglected area of literacy in the science classroom.

*Is Reading the Weaker Area of Content Area Literacy in Science?*

Much research and attention is given to early literacy at the elementary level (Biancarose & Snow, 2004). Decoding and word recognition are areas in which educators have a wide variety of resources at their disposal in order to help alleviate these issues. In fact, although 70% of older readers need some form of reading remediation, it is not in the area of decoding but rather in the area of comprehension (Biancarose & Snow, 2004; Snow, 2002; Thier, 2002). The challenges of reading at the secondary level are so much more difficult for educators to overcome because content area literacy is embedded in complex, subject-specific concepts and adolescents have such diverse motivational factors that will engage them in texts. In comparison with elementary school
students (Campbell & Kmiecik, 2004; Biancarose & Snow, 2004; Snow, 2002). In the United States only 70% of high school students graduate with a regular diploma (Biancarose & Snow, 2004). Many experts cite that students do not have the literacy skills to experience success with the high school curriculum, which correlates with the 60% of high school seniors who are reading below grade level (Biancarose & Snow, 2004; Campbell & Kmiecik, 2004).

The literature discusses the idea that science is a social language, similar to a foreign language with specific vocabulary, and that students may need to be immersed in the language (Gee, 2004; D'Arcangelo, 2002; Wellington & Osborne, 2001). As mentioned previously, science text is especially challenging because of the difficulty students have with not only the multiple levels of content specific vocabulary words but the other, non-science specific descriptive words in text as well. In addition, there are many connectives in science text that allow the author to convey the logic of science but are difficult for students to understand (Wellington & Osborne, 2001). As with other expository texts, science texts might be less engaging to read than other types of genres, which may also pose a challenge to motivate students to read (Snow, 2002; Wellington & Osborne, 2001; Alvermann, Qian & Hynd, 1995; Dickson, Simmons, & Kameenui, 1995; Campbell & Kmiecik, 2004). However, despite the need for students to have increased exposure to science texts, the little reading time allotted for in science class is devoted to reading instruction sheets for science experiments but not for reading text (Heselden & Staples, 2002). Textbooks are viewed as punishment by some teachers, or when teachers are out sick and need an easy activity to fill up time with (Wellington & Osborne, 2001). According to a study done by Lunzer and Gardner (1979) only 10% of 14 to 15 year old
students' science lesson time is spent reading. This study was corroborated by Wellington and Osborne (2001). Deliberately planned reading is done so rarely in science education that it must be the weaker area of literacy.

Most content area teachers do not focus on teaching students how to learn because they are focused on content (D’Arcangelo, 2002). Science teachers should not feel that teaching reading strategies is far removed from science content because reading is similar to applying the scientific method or problem-solving strategies (Padilla, Muth, Lund-Padilla, 1991; Holloway, 2002; Jacobs, 2002; Lundstrom, 2005; Snow, 2002). Reading parallels the scientific method because both processes require students to generate a purpose, analyze, draw conclusions, and communicate those conclusions (Holloway, 2002). The use of text in the classroom does not propose that hands-on activities need to be replaced with reading activities. Students can still explore scientific phenomenon but texts should be used to explain, compare, and synthesize information about the scientific principles at hand (El-Hindi, 2003; Lundstrom, 2005; Palincsar & Herrenkohl, 2002).

Strategies for Improving Reading Comprehension in Science

Strategies in content area reading should focus on transforming the process from a passive to an active task, with students becoming highly engaged in critical thinking activities (Heselden & Staples, 2002; Snow, 2002; Sanacore, 1995; Abell, 1992; Wellington & Osborne, 2001). Passive reading is when students are given no clear targets, are not clearly directed by the teacher, and it is a purely solitary activity. Active reading is done to accomplish a specific purpose, with exact instructions, and often is a shared activity. Most of the literature agrees that readers need to be engaged before,
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during, and after reading and most of the strategies detailed in the literature help students accomplish specific goals to increase comprehension at each of these time points (Topping & McManus, 2002; Abell, 1992; Jacobs, 2002).

As mentioned before, students come to a text with a vast amount of prior knowledge however. “Unless students activate their background knowledge, they don’t connect what they already know with what they’re learning in school” (D’Arcangelo, 2002, p. 13). Before reading strategies include helping students link their experiences to the text, access relevant prior knowledge, and acquaint students to the text’s organization and scope (Topping & McManus, 2002; Barton, Heidema, & Jordan, 2002; D’Arcangelo, 2002). Students do not know what is important and what to concentrate on while reading because of their lack of background knowledge (D’Arcangelo, 2002). A recurring theme in the literature is the need for readers to have a specific purpose so that they know what is important and what they are looking for in the text (Yore, 2004; Wellington & Osborne, 2001; Heselden & Staples, 2002; Jacobs, 2002; Holloway, 2002). In fact, students can be taught to read the same text for different purposes and adjust their reading strategies depending on that purpose (Snow, 2002). Some strategies involve the teacher giving students specific purposes, while other strategies involve students developing purposes together with the teacher; debate exists in the literature as to which type of methods (teacher directed versus student centered) are more effective (Padilla, Muth, Lund-Padilla, 1991; Biancarose & Snow, 2004; Ivey, 2002; Snow, 2002). In addition to generating a purpose, before reading strategies often include reviewing the organization of the text structure with students so that they can decide how to prioritize their own learning (Holloway, 2002; Dickson, Simmons, & Kameenui, 1995; Topping &
McManus, 2002; Heseldon & Staples, 2002). The before reading strategies may be viewed as so crucial to comprehension because, "The more knowledge and skills that students bring to a text, the better they will learn from and remember what they read."


Students' prior knowledge often times conflicts with what the text states about certain concepts (Roth, 1991). Students need strategies to help struggle with the differences between the text and their thinking and reorganize their own conceptual framework. They need strategies while they are reading to help them engage in meaningful learning; activating prior knowledge but integrating new learning as well (Roth, 1991). Good readers should keep track of questions or concerns that may conflict with their prior knowledge; this is displaying evidence of metacognition (Thier, 2002; Barker, 2004; Biancarose & Snow, 2004; Abell, 1992). Students should begin making personal connections and interpretations of the text with supporting details and convincing evidence (Thier, 2002; Topping & McManus, 2002). However, in a study by Alvermann, Qian, and Hynd (1995) simply "encouraging students to look back in the text for evidence that will support their answers does not appear to be an effective means for helping ninth-grade students modify their intuitive understanding about a complex science concept" (p. 152). While reading students should also respond to the text, consolidate ideas, and understand the logic behind the sequence of information (Topping & McManus, 2002; Roth, 1991; Thier, 2002; Barton, Heidema, & Jordan, 2002; D'Arcangelo, 2002). To achieve enduring understanding of the text, every student needs to become aware of his or her own reading habits and learn to apply strategies that are natural or intuitive (Thier, 2002; Topping & McManus, 2002). However, as with the
before reading strategies, there is debate in the literature as to whether teacher directed methods or student centered methods are best for increasing comprehension. Some authors advocate students modeling the teacher and having opportunity to practice strategies while others advocate interactions between students and teacher as well as students and students so that each member of the classroom begin noticing how different readers make sense of the text, what strategies readers use to make sense of the text, and allow students to try out others' strategies for interacting with the text (Schoenbach et al., 2003; Heselden & Staples, 2002; Snow, 2002; Padilla, Muth, Lund-Padilla, 1991; Biancarose & Snow, 2004; Sanacore, 1995).

After reading students must question if they understood the text and compare the information in the text with what they already know (D'Arcangelo, 2002; Padilla, Muth, Lund-Padilla, 1991; Abell, 1992; Snow, 2002). Strategies involved should focus on deepening students' responses to the text, consolidating facts and ideas, extending responses, and connecting with other texts (Roth, 1991; Topping & McManus, 2002; Snow, 2002; Palincsar & Herrenkohl, 2002). Unlike the before and during strategies, much of the literature focuses on the importance of student collaboration in this phase in order to generate shared cognitive meanings of the text (Palincsar & Herrenkohl, 2002; Heselden & Staples, 2002; Snow, 2002; Baker, 2004). Students need to be given opportunities to help their peers revise and reflect on their understandings of the text and to begin demystifying the invisible process of reading (Wellington & Osborne, 2001; Schoenbach et al., 2003; Biancarose & Snow, 2004).

The unifying theme between the before, during and after reading strategies is that fluent readers can access prior knowledge, hypothesize and predict, visualize, monitor
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their comprehension, and use strategies to adjust for miscomprehension. The job of the teacher is to show non-fluent readers what fluent readers do intuitively. However, as noted previously, not only does it appear that students have an easier time recalling more ideas from narrative texts than from expository texts, according to Dickson, Simmons, & Kameenui (1995), but this may also be effecting their motivation to read expository texts in science. In fact, according to Campbell and Kmiecik (2004), teachers in the greater Chicago identified motivating students as the greatest challenge they faced in content area literacy. Linking hands-on activities in science with literacy may be a solution to this challenge (Lundstrom, 2005).

As illustrated in this review, there are many avenues of controversy over how specific literacy strategies are best implemented in order to increase student comprehension of expository texts. The general argument illustrated is a pedagogical one that may best be answered with further research. One research method that could be utilized to explore these discrepancies is lesson study.

Lesson Study: The Process and Its Emergence in the United States

Bush (2003) has said there are four different behaviors associated with collaboration: 1) Talk about practice; 2) Observing each other's practice; 3) Working on curriculum; and 4) Teaching each other. Via these behaviors knowledge is both created and shared amongst group members. Lesson study involves all of these processes through groups of teachers meeting regularly over a long period of time to work on a series of research lessons, to design, implement, test, and improve them (Hiebert & Stigler, 2000; Fernandez, 2002; Fernandez, Cannon, & Sonal, 2003; Fernandez &
Chokshi, 2002; Fernandez & Yoshida, 2004; Lewis, 2002). The process is cyclical and involves a series of research steps (Lewis, 2002, see Appendix A).

The first step is to define the research problem (Hiebert & Stigler, 2000; Fernandez, 2002; Fernandez, Cannon, & Sonal, 2003; Fernandez & Chokshi, 2002; Fernandez & Yoshida, 2004; Lewis, 2002). This will motivate and direct the work of the lesson study group (i.e., how to improve students' understanding of adding fractions; how to help students learn mathematics from each other, not just from the teacher; how to foster students who are independent learners; how to increase critically thinking of students). In order to identify a research problem, teachers may find weaknesses in students that are not found by looking at test scores, but by interviewing them, by achievement on special assessments, and by making observations of students in one another's classrooms (Fernandez & Chokshi, 2002). One teacher may notice that their students have become complacent, non-independent problem solvers and may try to change this trait by incorporating this focus into the lesson study agenda. Teachers must working collaboratively to focus and shape the problem until it can be addressed by a specific lesson or series of research lessons (Hiebert & Stigler, 2000; Fernandez, 2002). Now the teachers need to focus on selecting a lesson topic that will not only align with their research problem but might also be in an area that students specifically have difficulty in, they themselves have difficulty teaching, that is typically “boring” for students, aligns with critical content standards or is introducing a new concept (Lewis, 2002; Fernandez & Chokshi, 2002). Once both the research problem and lesson topic are identified, teachers may uncover what their colleagues have done regarding the particular
problem or what is recommended by other educational groups on how students’ learning is maximized in that content area (Hiebert & Stigler, 2000).

After a focused research problem is identified and a specific lesson topic is chosen, the group plans a lesson collaboratively (Hiebert & Stigler, 2000; Fernandez, 2002; Fernandez, Cannon, & Sonal, 2003; Fernandez & Chokshi, 2002; Fernandez & Yoshida, 2004). The group may choose to look at other effective lessons on the topic and model after them. Fernandez and Chokshi (2002) recommend that teachers should improve the best lessons already available. When planning the lessons, it may be more beneficial to split larger groups into smaller groups or even pairs of teachers (Fernandez & Chokshi, 2002).

The third step involves one teacher teaching the lesson and others observing and possibly videotaping the lesson (Hiebert & Stigler, 2000; Fernandez, 2002; Fernandez, Cannon, & Sonal, 2003; Fernandez & Chokshi, 2002; Fernandez & Yoshida, 2004). One group member implements the collaboratively designed lesson plan while others observe and evaluate what works and what does not work. While observing the lesson, the observer usually writes careful notes right onto a copy of the lesson plan and often may require observers to denote the time course of each observation in order to make accurate claims in the next step of the cycle (Watanabe, 2002; Fernandez, 2002). To decide if the goals of student learning were achieved, the observer and teacher may wish to look at the method used by the majority of students to solve a particular problem (Fernandez, 2002).

The fourth and fifth steps involve the collaborative group evaluating, reflecting, and revising the lesson plan (Hiebert & Stigler, 2000; Fernandez, 2002; Fernandez, Cannon, & Sonal, 2003; Fernandez & Chokshi, 2002; Fernandez & Yoshida, 2004).
Based on specific observations and reflections made by the teachers, lessons are revised and may even require new materials, new activities, or new questions. During the revision process teachers specifically look for students misunderstandings revolving around certain subtopics. To improve comprehension they may change the wording of the problem posed, the order in which material is presented, or the types of follow-up questions that are employed to assist in knowledge building (Hiebert & Stigler, 2000). If the teachers split into smaller collaborative groups it is beneficial to be together in the larger group when coming back to discuss the success of the lesson (Fernandez & Chokshi, 2002).

The cyclical nature of lesson study becomes evident at this point because steps four and five are repeated; the revised lesson is taught, observed by others, and undergoes final revisions (Hiebert & Stigler, 2000; Fernandez, 2002; Fernandez, Cannon, & Sonal, 2003; Fernandez & Chokshi, 2002; Fernandez & Yoshida, 2004). In this case usually another teacher implements the lesson plan while others watch and evaluate. The final product of lesson study is a well-developed lesson plan that can be shared with other colleagues in the form of a school book or even shared with others in the profession (Hiebert & Stigler, 2000; Fernandez & Chokshi, 2002). The result of lesson study is reflective practice that will ultimately spill over into the teacher’s everyday lessons.

Lesson study involves bringing together teachers to discuss lessons they have planned together in detail and have observed unfold in the classroom. Lesson study usually involves 10 to 15 hours of group meetings between 3 to 4 week period of time (Fernandez, 2002). The goal in Japan (where lesson study originated) is to perfect a few lessons a year, which ultimately helps Japanese educators teach the other 182 lessons
more effectively (Fernandez & Chokshi, 2002; Hiebert & Stigler, 2000). This leads to the question of why and how lesson study has emerged in the United States if it is a Japanese professional development construct.

In 1995 and 1999, a sampling was done internationally of eighth grade mathematics classrooms (Hiebert & Stigler, 2000; Ferrini-Mundy & Schmidt, 2005). Videographers, native to each country, went to eighth grade mathematics classrooms and videotaped lessons. The data collected was compiled for the Third International Mathematics and Science Study (TIMSS). The study was funded by the United States government through the National Center for Educational Statistics and the National Science Foundation. Data from the videotapes was turned into information: impressions and images of teaching were recorded as well as quantified results that indicated how certain features of teaching occur in each country. The TIMSS video studies were performed in order to gain further insight into mathematics teaching in the United States, to compare United States teaching strategies with those in Germany and Japan, and to examine the impact of recent reform efforts on classroom practices (Hiebert & Stigler, 2000).

The information compiled from the videotapes addresses the elements that interact together in the classroom that effect student learning. Hiebert et al. (2005), explain that it is the interaction of the elements, the system, that determines the learning conditions and not each element in isolation. However, the authors analyzed a variety of aspects of the lessons videotaped in Japan and the United States and separated each element.
One element Hiebert et al. (2005) noted was that in the United States classrooms, problems in math were very routine and were not imbedded in very much context. On average, 34% of problems in United States classrooms were application compared to 74% in Japanese classrooms. Another key component to lesson structure in the United States is the prevalence of practicing problems rather than creating new problems, developing new procedures, or analyzing problems and deciding on appropriate procedures to apply. In 75% of United States math classrooms private work time is spent on practice time, compared to 28% of Japanese classrooms. In general, United States lessons are requiring students to do less critical thinking and more practicing procedures. In addition, the authors noted that a significantly greater amount of time was spent in United States classrooms on review compared to developing new knowledge. In all of the higher achieving countries, more time was devoted to developing students' knowledge of new material rather than reviewing old material. When achievement results were quantified, the United States ranked below the international average, while Japan scored within the top three countries (Hiebert & Stigler, 2000; Ferrini-Mundy & Schmidt, 2005).

In 2003, another TIMSS study was performed with 47 countries participating in the eighth grade comparisons in which 8,912 United States eighth graders in 232 schools were assessed (Ferrini-Mundy & Schmidt, 2005). This study, however, was purely achievement oriented and did not analyze classroom practice or curriculum differences. Although the United States did score above the international average, Japan still was ranked among the top five countries and scored 60 points higher than the United States in mathematics achievement (Mullis, Martin, & Foy, 2005, see Appendix B).
From the data from the TIMSS studies, researchers made some of the following suggestions to improve student achievement: 1) reduce professional isolation; 2) create a system for testing, accumulating, and sharing teaching knowledge bases; and 3) create clear and widely accepted student learning goals (Hiebert et al., 2005). "Much time has been wasted in the United States studying achievement scores and guessing what individual features of teaching should be changed to improve these scores" (Hiebert et al., 2005, p. 128). Hiebert and Stigler (2000) have suggested that teachers use lesson study to investigate and improve pedagogy based on these suggestions.

Linda Darling-Hammond has said, "Teachers learn just as their students do: by studying, doing, and reflecting; by collaborating with other teachers; by looking closely at students and their work; and by sharing what they see" (Stallings & Koellner-Clark, 2003, p. 501). However, despite the frequent use of the word collaboration in the United States’ education community, collaboration in the United States is often times very neglected (Friend, 2000). In a recent survey, a large majority of teachers said they had never observed other teachers but 75% stated they would like to observe other teachers at work (Fullan, 2001). With the paradigm of professional development shifting to where learning experiences are cooperative and collaborative and learning outcomes are shared with the community, lesson study is now being viewed as a possibility amongst other models of collaborative efforts (Harada, 2001).

Comparing Lesson Study with Other Collaborative Models

According to Harada (2001), the old method of professional development was focused on taking compiled data and lecturing to educators on best practices while new
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modes of professional development are leading educators to investigate and develop best practices through discussion, implementation, and reflection. Professional development in the past was a summative activity, often times with an outside expert being present for a one-day workshop or conferences. The emerging paradigm is shifting to an ongoing assessment of practice where educators are given opportunities for application and feedback over a long period of time (Hiebert & Stigler, 2000; Harada, 2001; Stigler & Hiebert, 1999). Although the literature addresses other models of collaboration, lesson study allows teachers to utilize this changing professional development paradigm to not only examine pedagogy but to increase student learning.

Collaborative inquiry and study groups are one methods of professional development in the literature (Bray, 2002; Harada, 2000; Herner, 2000). Collaborative inquiry involves developing a question that is of interest to the collaborators about their daily practice, reflecting on it, and investigating it. A good inquiry question, according to Bray, is one in which the answer to the question is not explicit and that group members will be able to investigate. An example inquiry question cited was, “How can we improve our practice as teachers” (Bray, 2000, p. 87)? Group members would then reflect on whether they believe their current practices are “useful, ineffective, or of uncertain value” (Bray, 2000, p. 87). The group then may decide to try out new practices and reflect on whether or not they were an improvement. One group in the study found that humor was important to their classrooms and tried to delineate why this was important (Bray, 2000). In the other collaborative model, study groups, the topic chosen is usually one that is in response to a problem or area of interest shared by group members (Herner, 2000). The final outcome produced by the group is to interpret the
educational research findings in the literature and present to the school, conference, or write a paper to be published.

Although collaborative inquiry is a method that helps shape teachers’ day-to-day work experiences more so than that of study groups because it is more imbedded in teachers daily work experiences, it still does not explicitly mention that it helps shape individual lessons and lesson planning (Fernandez, 2002; Fernandez, Cannon & Sonal, 2003; Hiebert & Stigler, 2000; Bray 2000; Herner 2000). In Japan, the lesson is viewed as the ultimate place to improve learning because it is the where “goals for students’ learning, attention to students’ thinking, analyses of curriculum and pedagogy, and so on” occur (Hiebert & Stigler, 2000, p. 11). Lesson study specifically targets what instructional goals need to be in place in order to elicit student learning and targets student qualities that influence that learning, while collaborative inquiry does not cause teachers to focus on increasing student learning per se. In fact, the majority of the benefits of collaborative inquiry discussed by Bray (2000) revolved around the personal feelings of the participants; in particular, that the groups became small learning communities that increased cohesiveness amongst its members. This is one of the myths of collaboration, as discussed by Friend (2000), that comradary and cohesiveness amongst faculty members is the most important outcome of a collaborative effort: “Instead, collaboration is the conduit through which professionals can ensure that students receive the most effective educational services to which they are entitled” (Friend, 2000, p. 131). Therefore, like the goal of lesson study, collaboration should be to ultimately increase student learning and student performance.
Another model in the literature that addresses the shifting professional development paradigm is the Designs for Learning model (McCarthy & Riley, 2000). Designs for Learning is organized around 10 designed elements:

1) Student data – teachers examine student data and determine improvement needs
2) Planning – these are long-term processes that take into account individual learning needs imbedded in school goals
3) Time – allocated to teachers
4) Leadership – is encouraged by administration
5) Content and pedagogy – is encouraged to be developed and refined
6) Inquiry – is promoted and encouraged
7) Collaboration – collegial work balanced with individual learning
8) Adult learning – good teaching and learning environment
9) Support – provided from both school and community
10) Accountability – student achievement goals met as a result of collaborative efforts

Although this article makes mention of many of the same goals as that of lesson study (Hiebert & Stigler, 2000; Fernandez, 2002; Fernandez, Cannon, & Sonal, 2003; Fernandez & Chokshi, 2002; Fernandez & Yoshida, 2004; Lewis, 2002), it does not give a specific outline for how teachers can develop and refine content and pedagogy nor does it address specific goals for collaboration. In fact, according to Friend (2000), it is often times assumed that educators have intuitive collaboration skills when in actuality these skills need to be honed, nurtured, and carefully taught. Friend (2000) commented that
many professionals have few staff development opportunities devoted to the topic of collaboration and spend little time in educator programs exploring this issue with colleagues. With this in mind, a more structured and goal focused method of collaboration may be appropriate. Although this model does fit with the teacher-as-expert paradigm, unlike other administrator-directed models of collaboration in the literature (Donaldson & Stobbe, 2000), it is missing key components such as specific focus on lesson design that are necessary to bring about data based improvement (Lewis, 2002).

Each of these models fit the criteria of collaboration as outlined by Friend (2000), where each individual of a group is committed to a shared goal, communication skills are crucial and required throughout the course of the collaborative session, all individuals must interact on a somewhat equal level, and participation is completely voluntary. However, lesson study is not just a collaborative model, but it also helps teachers uncover how to improve student achievement not just what needs to be improve (Lewis, 2002). Lesson study provides an outlet for teachers to become researchers in their own classrooms by asking questions such as: “How did students’ knowledge and understanding of the topic change over the course of the lesson and unit? Do students posses the basic personal qualities needed for learning? Are students well-organized, responsible, and able to listen and respond to one another’s ideas?” (Lewis, 2002, p. 10)? Students in the United States are in desperate need to become more responsible, organized, and responsive classroom participants (Lewis, 2002). One target in lesson study can be to incorporate those goals into each lesson. Although there is some mention of other collaborative practices in the university setting that may be more focus on
teachers as researchers (Corvel et al., 2003; Louie et al., 2003), none of the models described in this review demonstrate a researcher lens while engaging in collaboration as does the lesson study model (Hiebert & Stigler, 2000; Fernandez, 2002; Fernandez, Cannon, & Sonal, 2003; Fernandez & Chokshi, 2002; Fernandez & Yoshida, 2004; Lewis, 2002). Teachers who actively participate in research, are better able to see how teaching pedagogy is created, understood and transmitted to others (Bush, 2003). The data collected by many researchers is very limited to standardized tests, which can be a very narrow perspective of student achievement (Lewis, 2002). Lesson study is a means for bringing data based improvement into schools by valuing teachers and teacher input.

A shift is beginning to take place that is changing teaching to an individualized endeavor to that of a professional community (Bush, 2003). In addition, the focus needs to shift from teaching at the center to becoming learners at the heart of the issue who are proficient, reflective educators. Teachers may then begin to see themselves as leaders in curriculum and instruction and not just classroom managers. Teachers need to use research in cognition and intelligence to impact their work in education (Bush, 2003). Will lesson study help them accomplish these goals? Although lesson study is a well-established professional development model in Japan, it cannot be simply transferred to the United States without some careful modifications to adjust for cultural differences (Hiebert & Stigler, 2000; Fernandez, Cannon, & Sonal, 2003; Fernandez, 2002).

Adapting and Measuring the Success of Lesson Study in the United States

Educational change is necessary in the United States because teachers feel frustrated, burned out, and are overwhelmed with their responsibilities revolved around
improving student learning (Fullan, 2001; Campbell & Kmiecik, 2004; Johnson, 2003; Bush, 2003; Biancarose \& Snow, 2004). The best starting point for increasing teacher involvement centered on improving student learning is collegiality. "We are talking about reculturing the teaching profession—the process of creating and fostering purposeful learning communities" (Fullan, 2001, p. 136). However, this is a stumbling block when implementing lesson study where, unlike Japan, United States teachers often work in isolation and independently without being encouraged to work together as a team (Hiebert \& Stigler, 2000). Since lesson study involves observing and being observed by other teachers, this has been found to cause some problems when implementing the process in this country (Stewart \& Brendefur, 2005; Fernandez, 2002). A study by Leonard and Leonard (1999) recommended that administrators should allow for collaboration to happen in its purest form that includes being spontaneous, voluntary, and grounded in shared goals; not necessary being forced to collaborate (Bush, 2003). Keeping this in mind, United States teachers may wish to videotape lessons at first and gradually acclimate into each others' classrooms, although videotaping may not be as an effective method of data collection as in person observations (Fernandez, 2002; Fernandez \& Yoshida, 2004; Stewart \& Brendefur, 2005).

Another stumbling block many United States teachers have when trying to implement lesson study is keeping the researcher focus of creating hypotheses that are testable, designing appropriate means for exploring hypotheses, weighing evidence to determine success of hypotheses, and generalizing research findings to other contexts (Fernandez, Cannon, \& Sonal, 2003). For example, in the study by Fernandez et al. (2003), the teachers choose to focus on "fostering students' problem solving and
responsibility for learning.” However, during most of their conversations they focused primarily on just designing a lesson rather than on their research question and discovery process. The teachers finally did realize however, that the debate about how students would learn a topic best in the classroom could be illustrated by simply implementing the lesson and that experimentation could lead to concrete teacher learning. When the teachers observed lessons they were not skilled at recording and collecting data to determine the success of their hypotheses. This impeded the discussions during the reflection period because the teachers did not have specific pieces of evidences to support their generalizations and claims. Finally, the teachers in the study still did not ask questions like why do students solve problems in particular ways, which did not allow them to interpret their inconsistent generalizations. These difficulties in keeping a researcher lens may arise because teachers in the United States may not be accustomed to critically analyzing their own teaching practices. Unlike Japanese teachers, who are used to this mode of professional development, teachers in the United States are not encouraged or have no means of contributing to the refinement of their own skills or the gradual improvement of teaching methodology (Hiebert & Stigler, 1999). However, teachers are beginning to be more encouraged to investigate their own practices and many school districts are placing a priority on improving teacher education and increasing opportunities for teachers’ to learn (Hiebert & Stigler, 2000). It may be important then for teachers to get training at particular skill workshops but then have opportunities to work one-on-one and in groups to receive and give help and to converse about implementing lesson study (Fullan, 2001; Fernandez, Cannon, & Sonal, 2003).
Fernandez et al. (2003) also suggests possibly consulting with Japanese teachers on how to execute a researcher lens in the classroom. One important aspect of lesson study that United States teachers do not usually follow through on is the completion of a written report detailing the results of the lesson study (Fernandez & Chokshi, 2002). Not only does a written report help other teachers become informed about the issues involved with the experience, but it allows a full reflective process to be completed by the teachers involved. Because accountability is such an important piece of collaboration, this may need to take the form of administration involvement in the United States (Friend, 2000). Increasing disclosure will not only give other teachers a research base when researching the best methods for teaching particular content area topics but will help determine the success of the lesson study model in the United States.

According to Fullan (2001), lesson study will be successful in the United States if it results in:

- Teachers pursuing a clear purpose for all students' learning.
- Teachers engaging in collaborative activity to achieve the purpose
- Teachers take collaborative responsibility for student learning
- School-wide teacher professional communities affect the level of classroom authentic pedagogy, leading to student performance
- School-wide teacher professional communities affect the level of social support for student learning, leading to student performance

As previously mentioned, the main objective of any collaborative model should be to increase student learning (Friend, 2000). However, in the past, success of professional
development initiatives often involved assessing the inclusion of specific strategies into the course of lesson plans (Hiebert & Stigler, 2000). For example, successful professional development was viewed as the use of cooperative learning groups or problem-based learning in daily lesson design. This is marginal teacher growth and has very little impact on student learning (Hiebert & Stigler, 2000). Since lesson study is focusing on teachers addressing specific modes of academic learning such as: did students make connections, notice patterns, design and solve problems appropriately? teachers will go beyond simply implementing strategies and begin to explore reasons why the lesson is designed a particular way, anticipated responses of students in order to target specific misunderstandings, and suggested responses by the teacher to prevent students' further misconceptions (Lewis, 2002; Hiebert & Stigler, 2000). Therefore, assessing lesson studies success should be based on comparing student achievement scores and assessing teacher learning (Barrett & Riggs, 2004).

One anticipated success of lesson study implementation in the United States, that many teachers have already found, is that teachers grow and develop in many different areas. In a recent study, not only did teachers' lesson planning become more student-centered and focused on their desired results, but also their instruction was brought to a higher level (Stewart & Brendefur, 2005). Many teachers in the study were able to overcome their fear of being observed and brought their level of collaboration to a new place. "Working on improving teaching yields teacher development, rather than vice versa. Designing and testing lessons provides a rich context in which teachers can improve their own knowledge and skills. While teachers are producing shareable work, they are engaged in exactly the kind of learning that they need to become more effective
teachers. They must learn more about the subject, about their students' thinking, about alternative pedagogies” (Hiebert & Stigler, 2000, p. 12). With any model of collaboration, success should be that the sum is greater than the individual parts. The success of one individual is one thing but the success of the group should be even greater after the collaborative effort (Bush, 2003). The success of lesson study should be measured by the level of learning and increased achievement by the overall educational system in the United States.

When teachers focus on students’ construction of knowledge, disciplined inquiry, and value beyond school, achievement has been shown to increase (Stewart & Brendefur, 2005, p. 685). One way to integrate higher order thinking, deep knowledge, substantive conversation, and connection to the world beyond the classroom is by incorporating literacy into the content areas. In the past, literacy, especially reading expository text, has been viewed as a passive process. However, the strategies overviewed in this review help illustrate ways to change that process from passive to active. Despite the general consensus in the literature that teachers should implement before, during, and after reading strategies, there was significant debate over whether teacher-directed or student-directed methodologies were more effective at increasing student comprehension. Due to the unique research nature of the lesson study collaborative model, this method may be a superior method in identifying strengths and weaknesses in science students’ comprehension abilities while implementing these various methodologies. As mentioned by Campbell and Kmiecik (2004), motivation was the greatest challenge teachers faced in content area literacy. Because lesson study allows for the incorporation of a research question, as well as a specific content focus, it allows teachers a broader focus for
exploring classroom challenges such as investigating the effect of motivation on comprehension of science texts.
Methodology

Two implementations of the lesson study were completed. One was completed with teachers one and two and the other was completed with teachers one and three. All three teachers had worked in a collaborative relationship previously before beginning the lesson study process.

Participants

Three teachers were involved with the lesson study process. All three teachers were provisionally certified teachers in New York State working in the same public high school. Teacher one (the author), is enrolled in a Math, Science and Technology education graduate program at Saint John Fisher College where she is completing her graduate thesis. Teacher two has a science bachelor's degree, has completed her education master's degree and is completing her permanent certification. She is a tenured teacher in the district. Teacher three has an education bachelor's degree with a concentration in science and is completing her master's degree in liberal arts. She is also a tenured teacher in the district.

The students involved in the process were public high school students enrolled in Living Environment. Their ages ranged from fourteen to sixteen years old, socioeconomic status was middle class, and were predominately Caucasian. In the classes in which the lesson study was performed and evaluated, no students had an I.E.P (individualized educational program) and five students had a 504 plan (a plan with some testing modifications, but no additional classroom support).
Apparatus

Teacher one and teacher two used a cancer cards activity (modified from the National Cancer Institute) and an anticipation guide as a literacy strategy (see Appendix C). Teacher one and teacher three used a purpose guided notes sheet as a literacy strategy (see Appendix D). In addition, teachers one and three used the following materials: filter paper soaked with sodium hydroxide and dried, non-soaked filter paper (these were cut into squares), plastic cups, pipettes, phenolphthalein, capped vials, vial racks, tweezers, scenario cards.

Procedure

The first implementation of the lesson study process involved teachers one and two, while the second implementation of the lesson study process involved teachers one and three.

First implementation of lesson study.

Teachers one and two completed a cycle of lesson study in the course Living Environment during the cell unit. The goal of the lesson study was to increase students' motivation to read and increase their comprehension of science text. The topic of the lesson study was mitosis and cancer. Teacher one and two spent one hour discussing how to increase motivation to read the text and chose an activity (cancer cards) that would increase interest in the topic. Both teachers agreed that one method of increasing motivation was to increase interest in the topic. The second half of the initial teacher discussion was spent on what type of literacy strategy would be employed to help students comprehend the text. Teacher one modified the cancer card activity while teacher two modified the anticipation guide.
Teacher one and teacher two met for another hour session to discuss the logistics of the lesson and decided on specific questions to help students understand the connection between mitosis and cancer. This session was tape recorded. The teachers spent fifteen minutes reviewing their schedules and deciding on an observation schedule.

Teacher one implemented the lesson first while teacher two observed and video taped the lesson. Teacher two recorded observations on a lesson study observation protocol sheet modified from D. Llewellyn (see Appendix E). Both teachers decided to look for instances where the students were making connections between mitosis and cancer. In addition, teachers looked for evidence that students were engaged by being on task and completing their sheets and having meaningful discussions.

Teacher one and two met during a thirty minute common period and discussed aspects of the lesson that needed improvement and what went well. The lesson was modified and implemented by teacher two while teacher one observed. Teacher one observed and recorded observations on the lesson study observation protocol sheet.

Second implementation of lesson study.

Teachers one and three completed a cycle of lesson study in the course Living Environment during the immune system unit. The goal of the lesson study was to increase students' motivation to read and increase their comprehension of science text. The topic of the lesson study was vaccines and immunity. Teacher one and three spent one hour discussing how to increase motivation to read the text and began planning an activity that would increase interest in the topic of immunology. Both teachers agreed that one method of increasing motivation was to increase interest in the topic. The teachers met for another one hour period and began designing an immunology lab that
would correspond well with a science text and increase students understanding of immunity. The lab would also give the students a specific purpose, that of CDC interns, doing auxiliary research for the CDC. Teachers met for another one hour session and formally created the lab activity as well as the literacy strategy to help students understand the immunology reading.

Teacher one and three met to set up an observation schedule. Teacher one implemented the lesson while teacher three wrote observations on the observation protocol sheet. The teachers decided to look for evidence of mastery of concepts such as understanding of basic acquisition of immunity and the concepts involved antibody/antigen interactions. In addition, teachers were looking for evidence of engagement by completing all reading activities and staying on-task during the lab portion of the activity. The teachers met and discussed any changes that needed to be made to the lesson after school hours. Teacher three implemented the lesson with the modifications.

Long-term content area literacy improvement.

After continued implementation of literacy strategies throughout the course of the first half of the year in teacher one's classroom, students in all Living Environment classrooms in the Hilton Central School District were given a standardized midterm examination comprised of past Regents exam questions. Two questions on the midterm exam required students to read a four paragraph text on bacterial biofilms (a topic not discussed in class) and answer two multiple choice questions, 41 and 42 (from the June 2002 Regents exam, see Appendix F).
Results

The first lesson study process involved both teachers physical presence during the observation period and videotaping each other’s classrooms. Thus, the process was completely reiterative in the first implementation. During the second implementation, teacher one videotaped the lesson for feedback but was not invited to observe the revisions implemented in teacher three’s classroom.

First implementation of lesson study.

After the first implementation of the lesson study process, teacher two observed that students were having difficulty staying on task during reading and during small group discussions. Although some groups did discuss their answers at first, some students did not have evidence written down for each statement. Teacher two recommended that there be an increase in individual accountability. In order to do that, the teachers discussed some ways to improve and it was decided to tell the next class of students to be prepared to be a leader for each statement. That they would take turns in their small group explaining each statement and their supporting evidence, but they would not know which one they would be responsible for doing beforehand. A strength of the first round of the lesson study that both teachers noted was the large group discussion. Teacher one had placed a random small group’s anticipation guide on the overhead and asked the class if they agreed with all the answers. This prompted a very heated debate in which students were arguing with each other over whether or not they agreed with the statement “Cancer is most lethal when it is concentrated in one part of the body, rather than dispersed throughout the body” (see Appendix C). Students were debating that cancer would be more lethal as a tumor, concentrated all in one place where
it would grow massively and interrupt the body's normal functioning. The other students debated that cancer was more lethal when it started spreading throughout the body and started infecting other organs. Teacher one's role involved asking the students, "Why don't we change the statement? What should we add or take away from this statement so that we can all agree to keep this statement checked?" The teacher facilitated the changing of the statement to: "Cancer is less lethal when it is concentrated in one part of the body, rather than dispersed throughout the body" and took a class vote in order to ensure the change was one that everyone agreed on.

When teacher two implemented the lesson, teacher one observed that the students during the reading activity and small group discussions were on task and having mini debates. Most of the discussions revolved around the relationship between mutations and cancer, rather than the relationship between mitosis and cancer, which was one of the goals of the lesson. Teacher one observed that during the large group discussion, teacher two put a blank anticipation guide on the overhead and asked for volunteers to say state if they agreed or disagreed with each statement and give their evidence, which differed from the lesson plan implemented by teacher one. Volunteers gave their answers and teacher two validated. The discussion in the classroom turned toward the students asking the teacher specific questions about the causes of mutations, where the teacher was the disseminator of information.

The final reflection between teacher one and two resulted in both agreeing future implementations of this lesson would require the selection of a different article. Although mutations and cancer are an applicable part of the Living Environment curriculum, both agreed this particular article would have been more appropriate in the
genetics unit. An article with a more obvious focus on mitosis and cell division
becoming out of control in cancer would have been a more relevant article for this unit.

Both teachers also commented that the final, large group discussion did not result in a
debate; however, specific observations that may or may not have contributed to this
outcome were not mentioned. Finally, teacher two, who is participating in a study group
as part of professional development with the Hilton school district mentioned how much
more relevant the lesson study process was to the continued improvement and refinement
of teachers’ skills. She also commented on how she had never formally evaluated if
lessons work before.

Second implementation of lesson study.

Teacher three made observations of the CDC immune system lesson while teacher
one implemented it. Some positive observations made were that all of the students knew
what purpose they were reading for and were actively gathering evidence for their
purpose. Students in post-reading small groups were discussing and sharing their
information and not copying each others’ information but rather writing pieces of
evidence in their own words underneath the purpose questions they did not do. Small
group discussions included relevant and accurate discussions of what antibodies and
vaccines were. The cartoon sharing resulted in students being able to correctly explain
key science concepts related to antibodies being transmitted in breast milk, antibodies
attacking pathogens, and macrophages attacking viruses. After completing all of the
reading activities and moving on to the CDC lab after reading activity, teacher three
noted that many students did not know what to write in the conclusion column of the data
sheet. She recommended that they relabel this column and after discussion the teachers
decided to label it "Why is the patient displaying/not displaying immunity?" Another thing both teachers noticed was that although the students seemed very engaged during the entire process, during reading, during small groups, during the lab activity, and during presentations there were a lot of transition times in which some students were done with activities faster than other students. During those lagging times, students who were done were talking and getting other students off task that still needed to complete their work.

Teachers discussed this dilemma and teacher three decided that when she implemented the lesson she would have the students work on an immune system reading guide from the textbook during transition times to help minimize off task talking. Finally, in the after activity presentations, where students presented the findings from the activity, students appeared to not have thought very deeply about each patient scenario. All student small groups understood that it was antibodies in the patient's blood that was causing the interaction, however, they did not attempt to uncover why the person had the antibodies to the disease in their bloodstream.

Long-term content area literacy results:

Two questions on the Hilton Central School District's Living Environment midterm exam required students to read a four-paragraph text on bacterial biofilms (a topic not discussed in class) and answer two multiple-choice questions, 41 and 42 (see Appendix F). Data analysis was collected from all Living Environment students in the district and organized by instructor. As demonstrated in Table 1, 60% of teacher one's students got question 41 correct compared to 54% of the students in other Living Environment classes in the district. In addition, where only 4% of teacher one's students did not answer question 41, 11% of the remaining Living Environment students did not
answer the question demonstrated in Table 1. For Question 42, demonstrated in Table I.

81% of teacher one's students answered correctly and only 4% did not answer whereas

72% of the other teachers' students answered correctly and 11% did not answer.

Table 1

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<tr>
<th>Achievement of students of teacher one compared to average on Questions 41 and 42 on Living Environment Midterm 2006</th>
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Note: Asterisks indicate the correct answer for that question.
Discussion and Conclusion

The purpose of this study was to use lesson study in order to increase students' motivation to read and increase their comprehension of science expository texts. The literature was clear that increasing student motivation to read is a stumbling block for teachers but did not provide many strategies for how to do that (Biancarose & Snow, 2004; Campbell & Kmieciik, 2004). This study has found that linking activities to reading, as mentioned by various authors in the literature, actually helps engage students in reading activities (Lundstrom, 2005; Sanacore, 1995; Palincsar & Herrenkohl, 2002).

In both cycles of the lesson study process, after minor adjustments, students were actively engaged during the reading process. In the first study, an activity was used as an opening activity to generate interest in the topic and grab their attention. In the second study, the teacher prepared students for the role of being a CDC intern and testing patient's blood. Students needed to read the information and become knowledgeable in order to perform the auxiliary tests for the institution.

Another purpose for the lesson study was to increase students' comprehension of the science texts they were reading. Comprehension of mitosis and cancer was achieved in the first round of the lesson study process because none of the groups disagreed with the first statement, which dealt with mitosis and cancer. Through the large group discussion in teacher one's classroom, any misconceptions that students had about cancer in general were disseminated through peer debate. This was not the case in teacher two's classroom where the large group discussion turned to question and answer session. Students asked questions like, “I don’t get how you get cancer from tanning?” of the teacher and the teacher responded. The students did not get an opportunity to explain.
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persuade, and metacognitively process through difficult concepts out loud to peers. By processing in this fashion, students are more likely to actively construct knowledge rather than hold on to existing misconceptions while changing an answer on their paper. In addition, it did not give the teacher a chance to observe and note any misconceptions because students would simply change the answers on their papers unnoticed. In the second lesson study, comprehension of antibody/antigen interaction was evident through observations of small group discussions and through sharing out of their cartoon captions and CDC lab findings.

The literature is clear that active reading requires a purpose, which the motivational activities helped establish (Yore, 2004; Holloway, 2002; Jacobs, 2002; Heselden & Staples, 2002; Snow, 2002). In the first lesson study, the cancer cards helped establish that the reading would be about cancer, while the anticipation guide actually generated the purposes for reading the text. In the second study, the CDC role and problem was presented to the students and from that the students actually brainstormed their own purposes for reading. From there, the teacher selected three purposes (she knew would be addressed by the reading) and assigned groups of students to read the same text for a different purpose as mentioned by Snow (2002). These strategies helped students comprehend the text as noted by teacher observations.

In order to assess which factor impacted comprehension of science texts more, motivation or implementation of strategies, data from the 2006 Living Environment midterm exam was analyzed. Students from teacher one’s class, in which content area literacy strategies were continually implemented throughout the first half of the year, scored higher on two reading comprehension questions than the average Living
Environment student in the Hilton Central School District. Although students may have been intrinsically motivated to read about bacterial biofilms, the explanation is most likely due to the internalization of active reading strategies taught during class. The use of activities paired with reading, however, may have caused the switch for students becoming intrinsically motivated to read. Because the activities allowed students to see reading in a much more positive light, reading may have changed for students as something they will actually spend the time to complete, instead of merely skipping over.

The lesson study process appeared to be a successful tool in evaluating the success of literacy strategies. Friend (2000), warns of the misapplication of the term collaboration, however, teachers involved in this study had been involved with collaboration on a meaningful level many times before. As mentioned by teacher two, it was not often, however, that the teachers involved in this study had formally evaluated their lesson design efforts on the impact on student learning and achievement.

The first lesson study implementation went well because both teachers were very comfortable sharing their classrooms. Teacher one is a traveling teacher and shares a classroom with four other teachers on any given day and teacher two has shared a classroom with other teachers before. During the after lesson discussions, teacher one did not feel comfortable sharing with teacher two why the large group discussion did not result in a debate. This may have been due to the discrepancy in experience level with teacher two having more experience than teacher one.

The second lesson study planning stage went well however, the implementation of the recursive evaluation process did not proceed as well. Teacher three was unavailable to observe teacher one during the lesson implementation and it was videotaped instead.
Although the literature forewarns against the limitations of videotaping, due to the nature of the situation, it was unavoidable (Lewis, 2002). Teacher three did not invite teacher one into her classroom to watch the final implementation of the revised lesson. She may not have felt comfortable having teacher one observe her teach the lesson.

Part of the problem with lesson study being adapted to the United States, which was not mentioned in the literature, is that experienced teachers in the United States are not accustomed to writing and following detailed lesson plans on a daily basis. Most experienced teachers following a general outline and leave the detailed plans behind as they grow with experience. Teachers face increased pressure and responsibility of daily classroom life and do not have time to write or follow a detailed lesson plan. Teachers do not write down their methodology for generating student questions, for extracting meaningful debates, and for deepening conversations. These are skills they have developed and sometimes overlook as being important. However, these are important components of the lesson that many teachers need to include when creating their lesson plans to share with others and might end up producing the illusion that the lesson is unsuccessful if they are missing. Teachers cannot replicate lessons created by others because the actual implementation of the lesson is lost when just the student handout is passed on. This was apparent in the first lesson study lesson during the large group discussion.

Lesson study has provided a new tool for teachers to utilize in order to improve student classroom success at the level of the lesson. In the Hilton High School, there has been an increased interest in vocabulary comprehension. There are many teachers in the science department who utilize vocabulary lists or fill-in-the blank notes to teach students
vocabulary. However, according to Thier (2002), students should be able to apply
meaning to text and not merely memorize a vocabulary definition. A future avenue to
explore would be to apply lesson study to use literacy strategies in order to increase
students' comprehension of vocabulary words.

Teachers one and two disseminated the information learned about literacy and
lesson study at a district Superintendent's conference day. Teachers one and two shared
the methodology they used to design content area reading strategies and presented the
reiterative lesson study evaluation process. This should not only bring to light further
research opportunities for the area of literacy but also demonstrate the effectiveness of
the lesson study process in the United States culture as a means of professional
development. Teachers one and two are hoping that the presentation of the use of lesson
study to analyze the success of the content area literacy study will be beneficial for their
colleagues in their school district. In addition, they would like to see the use of lesson
study as a professional development opportunity for teachers in their district because it
gives teachers the freedom to study and improve individual lessons, which are at the core
of improving student learning.
References


Using Lesson Study


Lesson study is a recursive process that involves goal setting, researching, refining, and disseminating the lesson, and disseminating results (Lewis, 2002).
Appendix B

Data Compiled from the 2003 TIMSS Study

Data tables from the 2003 TIMSS study were modified to point out specific comparisons between the United States and Japanese achievement scores (Mullis, Martin, & Foy, 2005).

Exhibit 2.2: Multiple Comparisons of Average Mathematics Achievement for Knowing Cognitive Domain

Exhibit 2.3: Distribution of Mathematics Achievement for Applying Cognitive Domain
Appendix C

First Lesson Study Materials

Cancer cards and anticipation guide as utilized in the lesson study implemented by teacher one and teacher two.

Example cancer card:

<table>
<thead>
<tr>
<th>Age</th>
<th>Gene 1</th>
<th>Gene 2</th>
</tr>
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<tbody>
<tr>
<td>6</td>
<td>18</td>
<td>21</td>
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<td>15</td>
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<td>20</td>
<td>6</td>
<td>24</td>
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<td>25</td>
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<td>40</td>
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<td>12</td>
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<td>45</td>
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<td>16</td>
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<td>50</td>
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<td>17</td>
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<td>55</td>
<td>23</td>
<td>4</td>
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<td>60</td>
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<td>65</td>
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<td>70</td>
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<td>75</td>
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<td>95</td>
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<td>10</td>
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<td>100</td>
<td>24</td>
<td>11</td>
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</tbody>
</table>
1. Cancer is the result of mitosis that occurs repeatedly without the normal checks.

2. Cancer can result from a single genetic mutation.

3. Cancer is either environmental, or inherited, never both.

4. Cancer is most lethal when it is concentrated in one part of the body, rather than dispersed throughout.

5. All genetic mutations lead to cancer.

http://www.pbs.org/wgbh/nova/cancer/grows.html - For article contents
Formal lesson plan for first lesson study.

Unit: Cells  Date: October 14, 2005

Standards: Standard 4 Living Environment

Objective: Students will be able to identify the relationship between mitosis and cancer.

Anticipatory Set (Engage)
Students will be given green cards.
One student will be selected to pick a number 1 -25 at random. Students will be
told to circle that number (if they have it) in the "gene 1" column.
Second student will select a number 1 – 25 at random. Students will be told to
circle that number (if they have it) in the "gene 2" column.
Students will determine what age they have gotten cancer.
"So what determined if you got cancer or not?"
"What determined what age you got cancer?"
"What causes cancer?"

Literacy Activity (Explore)
1) Have each student read each statement and write if they agree or
disagree with each statement.
2) Each student will read silently, writing in important facts that support or
contradict the statement.
3) Students may change their original statement.

Small Group Discussion (Explain)
1) Assign students into groups of 3 (1 at each ability level)
2) Direct students to discuss/debate their answers.
3) If they agree on a point discuss what is the same/different about their
reasoning for believing that point to be true/false.

Large Group Discussion (Extend)
1) Choose a group that was engaged in a moderate amount of debate and
put their answers on the overhead.
2) Direct students to discuss/debate their answers.
3) If they agree on a point discuss what is the same/different about their
reasoning for believing that point to be true/false.

Closing/Evaluate: Once discussion has ended and a class consensus has
been reached students will toss a “think” ball around the room and name one
thing they learned about cancer.
Second Lesson Study Materials

Student directions for immunology activity.

Immune System Problem Solving Activity

Problem: You are a student interning at the CDC (Center for Disease Control). You have been asked to explore the reasons behind why certain patients have immunity to different diseases and others do not. You will be given different blood samples from different patients to perform tests on. However, you need to increase your background knowledge about what causes immunity and how the immune system functions.

Before you read the Background
You need purposes for reading. From the problem, write down some purposes for reading.

Purpose 1:

Purpose 2:

Purpose 3:

While you read the Background

Fill out the graphic organizer to help you gather important information about your purpose statements. This information will help you explain what is going on with your patients.

<table>
<thead>
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<th>Purpose 1:</th>
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<th>Purpose 2:</th>
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</table>
After reading the Background
Now you need to test your knowledge. Please write a cartoon caption underneath each picture. This should also describe the science behind the picture that you learned from the background reading as well.
Immune System Problem Solving Activity

Now that you are knowledgeable about immunity you are ready for your task at the CDC (Center for Disease Control). Don't let your Living Environment teacher down (s/he recommended you for the internship!!)

Directions: You will be given some background information about each patient from a history survey they filled out before their blood sample was taken.
Your job is to:
1) Perform an assay (test) to determine if the person has immunity to a particular disease
2) Use the background information on the card to determine why the person does or does not have immunity to the disease.
3) Record ALL information in the data table on the next page (remember the CDC keeps excellent records!).

*Note: You WILL be responsible for reporting your results (as determined by the CDC and your teacher) in some public manner or taking an exam on this information.

How to do the Assay
1) Please take the white disk with the antigen bound to it and place it flat onto the bottom of your Dixie cup with the tweezers. (The white disk that goes with your blood sample has the specific antigen for the disease you are testing for on it).
2) Put 5 drops of the clear blood sample into the Dixie cup on top of the white disk with the pipettor (It is clear because the red blood cells have been removed from it).
3) If the disk turns pink, this is a positive result. It indicates that something in the patient's blood has bound to the antigen on the disk.
4) If the disk stays white, this is a negative result; nothing in the patient's blood bound to the antigens on the disk.

Why is there a color change? There is a special chemical attached to the antigen. When it binds to something it changes color. If not, it stays colorless.
<table>
<thead>
<tr>
<th>Patient</th>
<th>Assay Results</th>
<th>Important Patient History</th>
<th>Conclusion</th>
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Using Lesson Study

Formal lesson plan for second lesson study.

Unit: Immune System Date: December 10, 2005 (2 hr. period)
Standards: Standard 4 Living Environment
Objective: Students will be able to identify the interaction between antibodies and antigens. Students will know how people develop antibodies against diseases.

Anticipatory Set (Engage)
Teacher reads the problem out loud. Really play up the fact that they will be testing blood samples from the CDC. (Tell them the story of how you know people there, etc.) Have students brainstorm purposes for reading (A.K.A – what do they need to know from the problem statement that don’t really understand?)

Literacy Activity (Explore)
4) Teacher picks three purposes from the brainstormed list (ones that will be addressed in the reading!)
5) Teacher assigns students to read the text for 1 of the three purposes and tells them to write down notes that answer the purpose question or anything they think has do with the purpose.

Small Group Discussion (Explain)
4) Assign students into groups of 3 (1 from each purpose)
5) Direct students to discuss their purpose,
6) Model how their group should NOT run – do not just copy each others notes!
7) Tell students to discuss why they wrote down each thing they did and explain about their purpose, they are the expert in their group (each person is taking down notes).
8) When they are finished discussing, have them take a look at each of the cartoons and write a cartoon caption explaining the science behind the picture (Encourage “Far Side” like humor 😂)
9) Have each group share out their best caption.

Individual Patient Testing (Extend)
4) Review directions for testing patients’ blood.
5) Explain that the disks have an antigen on it and ask the students what they think might be in the patients blood if they are going to test positive for the disease.
6) Each station has a different patient scenario and a different disk/blood sample. Have students rotate through all of the stations and complete their data table.

Small Group Presentations (Evaluate)
1) Break students into groups of 3 or 4 – Assign each group a patient to report on
2) Assign one student to be the recorder – give them a blank overhead and a marker
3) For their presentation they must say:
   a. What disease were they testing the patient's blood for?
   b. Were they immune to it?
   c. Why were they immune to it?
   d. What in their history (scenario card) gave you a clue about this?
4) Have students present to their peers. Disagreements should be mediated by the teacher.
Appendix E

Lesson Study Observation Protocol

Observation protocol used by teachers in the lesson study modified from D. Llewellyn (Saint John Fisher College).

Lesson Study Observation Protocol

Pre-Lesson

Basic Lesson Information:

Teacher ____________________________
Observer ____________________________
Date of Observation __________________
Lesson title _________________________
Subject/Grade Living Environment

Lesson Focus (circle one):
Engage Explore Explain Extend Evaluate

Lesson Emphasis (check all that applies):

Engage
- Providing "hook" for lesson introduction
- Demonstrating a discrepant event
- Uncovering misconceptions
- Assessing prior knowledge
- Demonstrating a principle or phenomenon

Explore
- Providing an opened-ended investigation
- Designing student investigations
- Recording data/collating evidence
- Following prescribed steps of a laboratory
Using Lesson Study

Explain
- Introducing new concepts
- Learning new vocabulary/facts
- Presenting background content information

Elaborate
- Providing problem-solving activity
- Completing an extended investigation
- Following prescribed steps of a laboratory
- Applying exploration to real-world situation

Evaluate
- Answering textbook short and/or open-ended questions
- Reflecting on readings and problems
- Writing reflections in a journal or notebook
- Preparing an oral or written presentation of evidence
- Completing homework sheets
- Completing performance assessments
- Making entries to a portfolio

Classroom Instruction (Check all that applies):
- Indicate major materials resources used during the lesson
  - Print materials - commercial textbook
  - Print materials - teacher-made
  - Print materials - trade books, magazines, etc.
  - Hands-on materials - commercial kits
  - Hands-on materials - district-produced kits
  - Hands-on materials - general laboratory supplies
  - Hands-on materials - models
  - Technology resources - computers
  - Technology resources - calculators
  - Technology resources - maps, charts, etc.

Structure of student work:
- Whole group
- Small group
- Pairs
- Individual

Student Engagement:
- Entire class is engaged in the same activity at the same time
- Groups of students are engaged in different activities at the same time
Class Discussion:
- Whole group lead by teacher
- Whole group lead by student(s)
- Small groups

During the Lesson

Comments: Record the time and observation throughout the lesson. Capture the salient interactions between the teacher and the students and among students as they work in groups.

<table>
<thead>
<tr>
<th>TIME</th>
<th>OBSERVATION</th>
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</table>
**Post-Lesson**

Rate each of the indicators from 1 to 5 for all categories. A rating of 5 indicates a “high” score and a rating of 1 indicates a “low” score. Your ratings and comments from the lesson will be used for the post-lesson reflection.

**Lesson Design:**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>The strategies of the lesson contributed to the purpose of the lesson.</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>The materials of the lesson contributed to the purpose of the lesson.</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>The lesson design encouraged student engagement.</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>The lesson provided adequate instruction in completing the task.</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>Adequate and appropriate materials were provided.</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>The pace of the lesson was appropriate.</td>
<td>5 4 3 2 1</td>
</tr>
</tbody>
</table>

**Content:**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>The content was appropriate for the lesson.</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>The information presented during the lesson was accurate.</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>The information presented during the lesson was relevant to the students.</td>
<td>5 4 3 2 1</td>
</tr>
</tbody>
</table>

**Engagement:**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Rating</th>
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</thead>
<tbody>
<tr>
<td>Students were engaged and involved during the lesson.</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>The lesson provided an opportunity for collaboration.</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>The lesson required critical thinking skills.</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>The lesson challenged students’ abilities.</td>
<td>5 4 3 2 1</td>
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</tbody>
</table>
Lesson Modifications and Areas for Improvement:
Using Lesson Study  72

Appendix F

Questions 41 and 42 of the 2006 Living Environment Midterm Exam

... Some of the most common and deadly bacteria do their mischief by forming a sticky scum called biofilm. Individually, the microbes are easy to control, but when they organize themselves into biofilms they can become deadly, said Dr. Barbara Iglewski of the University of Rochester.

Biofilms are actually intricately organized colonies of billions of microbes, all working in a coordinated way to defend against attack and to pump out a toxin that can be deadly. Once they are organized, the bacteria are highly resistant to antibiotics and even strong detergents often cannot wash them away or kill them.

Iglewski and colleagues from Montana State University and the University of Iowa report in Science that they discovered how the microbes in the colonies communicate and found that once this conversation is interrupted, the deadly bugs can be easily washed away. Using Pseudomonas aeruginosa, a common bacteria that is a major infection hazard in hospitals and among cystic fibrosis patients, the researchers isolated a gene that the bacteria use to make a communications molecule. The molecule helps the microbes organize themselves into a biofilm — a complex structure that includes tubes to carry in nutrients and carry out wastes, including deadly toxins.

In their study, the researchers showed that if the gene that makes the communications molecule was blocked, the Pseudomonas aeruginosa could form only wimpy, unorganized colonies that could be washed away with just a soap that has no effect on a healthy colony...

Adapted from: Paul Recer, “Researchers find new means to disrupt attack by microbes,” The Daily Gazette, April 26, 1998.

41. What is one characteristic of a biofilm?
   (1) presence of tubes to transport materials into and out of the colony
   (2) presence of a nervous system for communication within the colony
   (3) ease with which colonies can be broken down by detergents
   (4) lack of resistance of the bacterial colony to antibiotics

42. Which statement best describes Pseudomonas aeruginosa bacteria?
   (1) They cause mutations in humans.
   (2) They are easy to control
   (3) They cause major infection problems in hospitals.
   (4) They are deadly only to people with cystic fibrosis