Guiding the Inquiry Using the Modified Scientific Literature Review

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An ethnographic study explored how 41 grade 11 students enrolled in biology, chemistry, physics and psychology classes completed a modified scientific literature review (SLR). Researchers questioned whether the use of primary readings from peer-review science journals promoted increased student learning, the ability to handle scientific information, the stimulation of critical thinking skills, development of a deeper understanding of a scientific topic, and the preparation for collegiate research. Data were collected in four phases: Preliminary interviews; debriefing interviews after completion of the SLRs; content analysis of student work; and face-to-face interviews two years after the SLR unit with self-selected participants from the original sample. Findings indicate that students were able to successfully manage the scientific literature. All participating students made an "intellectual jump" in knowledge creation. Construction of new scientific knowledge was reflected in the ability to compare and contrast the scientific studies, as well as indicate exceptions, omissions, trends, and possible implications for future research. Thirty percent of students mention the SLR as one of the most helpful college preparation experiences.

Introduction

The purpose of this paper is to study the design of a modified scientific literature review (SLR) unit, as an instructional intervention, to overcome the constraints related to teaching science in traditional school settings. Science teachers and, by extension, their students are constrained by internal conditions of limited laboratory and classroom time and space, insufficient or dated equipment, and science education training as generalists. External societal conditions influence curriculum as well, including an over-dependency on science text-books, a limited trust in student-initiated, student-centered research, and an over-abundance of costly information sources and media available. The internal and external constraints of science in schools occur within an ever-expanding world of scientific information and study. A science teacher expressed his frustration in these words:

> I was stuck. Three weeks were left in the school year and I was hoping to delve deep in to the nature versus nurture controversy with my introductory psychology class. I had taken a copious amount of notes on a myriad of issues surrounding the topic and planned three weeks of

> intensive lecture-based classes. I envisioned myself as having to be the "know-it-all" on issues ranging from intelligence to birth order to homosexuality. Truthfully, I was overwhelmed as I lacked the time and scientific knowledge base to dig deep into these issues.
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> In the end, my three week nature-nurture seminar turned into an exercise in frustration for both myself and my class. Students did not respond to the daily lectures that lacked student interaction, and I became disheartened as my lessons, while rich in breadth, lacked the needed depth.
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> What was I to do? Well, off I went to the library to discuss my problem with our sage, the school librarian. After listening to my tale of woe, my friendly librarian suggested that I ask students to become experts on a topic pertaining to nature versus nurture. Students becoming experts and knowing more than I do about a psychological topic? How was this to be?
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> The concept of a scientific literature review was proposed to me and the rest has been a happy history! No longer are my kids disengaged from their learning. No longer is the content of my course lacking depth and no longer am I frustrated. Through collaboration with the library staff my students have produced startling research on topics meaningful to them as many have used the assignment to better their understanding of themselves and the world around them.
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> I have also found that true collaboration is only possible if all individuals involved leave their egos at the doorstep. Truthfully, during the research process, I do not have control of my class. I go from "head coach" to research assistant to the library staff. I am no longer the expert in my student's eyes. Instead, I am a learner as my knowledge on a researched subject is quickly surpassed by that of my student's. (Schmidt, Smyth, & Kowalski, 2008, pp. 11-12)

When the psychology teacher approached the high-school librarian for help, the librarians saw this as an opportunity to create a one semester curriculum unit for the *Introduction to Psychology* course. Such a unit would provide information-rich science and research lessons while piquing students' interest in particular scientific subject matter. As the science teachers and the high school librarians continued their dialogue, they focused on the problem of covering introductory level material for the psychology course and required material for the Advanced Placement (AP) Biology course. Students seemed unwilling or unable to sustain attention while sitting through information-laden lectures. Their teachers observed that they were not assimilating new information. The educators concluded that a new approach was needed. They began to ponder these questions:

- How do students best learn science?
- Can we engage students in the tasks of "real" scientists?
- How can a science teacher engage grade 11 high school students with scientific methods and introductory content in a particular subfield of scientific knowledge such as biology, chemistry, physics, environmental science or psychology?

After discussing a modified scientific literature review as a possible solution, an authentic approach led science teachers and librarians to formulate the following questions:

- What are the effects of the SLR on student learning?
- How can a SLR help students develop deep understanding of science outside of the science laboratory?
- How can educators use information and technology in the school library to create learning tasks that are relevant to what's happening in the classroom?

These preliminary questions drove a ten-year initiative that used Guided Inquiry (Kuhlthau, Maniotes, & Caspari, 2007) to teach students how to write a scientific literature review. The initiative was designed with a series of interventions to spark interest and stimulate the young, often uninitiated, student in the active, participatory role of the scientist in society. It was modeled after the professional scientific literature review which is usually employed by scientists to examine current and ongoing research before embarking upon new research. Because students are inexperienced in the subject matter, the SLR was modified to accommodate their lack of prior knowledge and training in scientific reporting and writing.

The question that frames the study described in this paper emerged from this context. How can a collaborative team of science teachers and school librarians design and implement a behavioral science unit of inquiry for grade 11 students to engage them in the content and process of scientific research?

Definition of a Modified Scientific Literature Review

A formal scientific literature review (SLR) is performed by a research scientist who has been trained in scientific protocols and has a working body of scientific knowledge which s/he brings to the literature review. The scientific literature is reviewed to examine prior scientific studies about potential research questions or hypotheses the researcher may choose to study. The modified SLR used in this study has a different purpose. It is an intervention that enables science teachers in the pure and behavioral sciences to introduce and educate their students to the excitement and content of "real time science." Table 1 displays the section of the modified SLR and the contents of each section.

Table 1 Design of the Body of the Modified Scientific Literature Review

Modified SLR SECTION	CONTENT OF THIS SECTION
Introduction	6-8 General Press Articles – provides summaries of newspaper, magazine, and other media to describe what the world is saying about the topic and to formulate the research question
Methodology	Description of How & Where General Press & Scholarly Articles were found
Results of Research	6-8 Peer-Reviewed Articles – provides summaries of the scientific studies
Analysis of Results	Provides comparisons and contrasts between studies indicating similarities, differences, trends, errors, omissions, and directions of future research

For the neophyte science student with little prior scientific knowledge or training, a research question that is less content-driven is needed. The modified SLR (See Table 1) serves to introduce the student to a high interest topic or question that addresses a scientific problem as it is manifested in the real world. The SLR also introduces the student to the scientific protocols used to study this question. For a grade 11 student, the modified SLR is often his or her first encounter with real scientists studying a scientific question. The modified SLR asks students to formulate a research question generated from their own prior knowledge and experience, as well as their curiosity.

Literature Review

Within the past three years, studies have demonstrated that the use of primary literature in the sciences is effective in developing scientific information handling skills and stimulating critical thinking in the sciences (Elrod, 2007; Hoskins & Stevens, 2007; Tribe & Cooper, 2008). Elrod espouses a collaborative process using primary source scientific literature to enhance student learning and enthusiastically support collaboration between the science department and the library:

> From the beginning, shared constructivist educational philosophy enables robust boundary-crossing discussions, toward the common goal of embedding information competence instruction in high level course learning outcomes. Through participation in the Literature-Based Scientific Learning project, the genetics professor learned how to more effectively involve students in authentic learning and thereby enculturate them into the ways of scientific discovery and scholarly communication. In so doing, she shifted the responsibility for knowing from instructor to student and observed that students were consequently less focused on 'learning to display knowledge' and more interested in 'learning to know.' (Elrod, 2007, pp. 690-691)

An "intensive guided analysis" approach to teaching science while using primary literature resources, C.R.E.A.T.E. (consider, read, elucidate hypotheses, analyze and interpret data), was developed to teach Biology majors in CUNY, New York City. The results of CREATE provoked original deep-knowledge among the students and stimulate[d] students' interest in research careers. The designers of the CREATE program describe the program in this way:

> We have tested modules focused on planaria regeneration and on optic nerve development. Our assessments indicate that CREATE students learn to critically analyze data and also gain new understanding of, and interest in, the research process and scientists themselves. Thus, CREATE humanizes research and researchers as it demystifies the process of reading/analyzing a scientific paper. (Hoskins & Stevens, 2007, p. 320)

The question of how educators inculcate primary literature into scientific instruction arises in the literature. "We need to examine when and how to mix didactic material and delivery with more significant student engagement with original material or data or simulations" (Ramaley & Haggett, 2005, p. 3). Henderson and Buising (2000, p. 109) suggest, "One way science educators can integrate writing, critical-thinking … into their curriculum … is by incorporating a collaborative … research paper assignment." Recent literature indicates that involvement in original scientific research develops critical thinking skills and stimulates student interest, which in turn motivates the student to reach high levels of understanding. "Peer-reviewed literature in science transmits the excitement and the methods of the scientific endeavor in a way that most textbooks do not, and has been used to enhance the learning process in higher-level classes" (Tribe & Cooper, 2008, p. 38).

Emboldened by data about the central role of the library in student learning (Lance, 1994), the excitement created by using peer-reviewed literature in the sciences to improve scientific learning (Tribe & Cooper, 2008), and the development of critical-thinking skills (Elrod, 2007; Henderson & Buising, 2000; Hoskins & Stevens, 2007), SLR designers embraced the role of the school librarian as both a teacher and innovator whose field of "information literacy arms a person [the student] with the skills to use information in a complex technological society for the construction of meaning" (Kuhlthau, 1995, p. 54).

Methodology of the Study

This ethnographic study examined 41 SLR papers written by grade 11 students and the behavioral responses of these students to the SLR assignment. The research questions asked in the study fall into four categories:

1. What were the topic choices and why were students motivated to choose them?

2. What information behaviors were exhibited? For example, did students display anxiety? Confusion? Confidence? Were they overwhelmed by the content?

3. What were the effects of SLR on student learning? Did they summarize and write results of their research? Did they apply higher order thinking to compare and contrast the studies, project trends or future research, and discuss omissions or errors within or among the studies? How did students feel upon completion of the SLR?

4. How did it affect the way they thought about science? Did the SLR project connect students to science in a positive manner?

The setting for the study was a library in a small independent college preparatory day school of 650 students, pre-K through grade 12. The upper school (high school) had, at the time of the study, 250 students enrolled from 30 towns in five New Jersey counties. The school is a tuition-based institution, representing an upper middle class to upper class socio-economic base. The majority of students come from suburban areas. However, the school has consistently maintained approximately 25% of its students on scholarship aid. Therefore, a sizeable number of students are less economically advantaged, coming from the cities of Plainfield, Newark, and Jersey City in New Jersey.

Ninety-five percent of the school's graduates go to college and graduate from four-year colleges and universities ranging from Ivy League to large state universities. Eight-five percent of the students are Caucasian, ten percent are African Americans, five percent are Hispanic, Asian, or other. The grade 11 class enrolled 48 students during the year of this study. Of these students, 50 percent were enrolled in one to three rigorous advanced placement (AP) courses which are accelerated courses that earn college credit. The other 50 percent of the student body range in abilities from low grade-level to above average abilities in the sciences. The grade 11 Psychology classes are considered to be less rigorous than "pure science" classes of Biology, Chemistry, or Physics. Routinely, students who decline to take a more difficult science class, or desire a second science course, enroll in the Psychology class so enrollment in Psychology often does not reflect the most motivated or academically gifted students. The 41 students observed in this study belong to a grade 11 class of 48 students. Seven students were excluded from the sample: One student was not enrolled in a junior science course; two students received incomplete grades; one student left school before the end of the year; and, three students failed to turn in papers.

The school librarian introduced the idea of a modified scientific literature review to a Psychology teacher of grade 11 students, ages 16 to 17. The proposal came after they discussed how to handle information overload in an *Introduction to Psychology* class. The school librarian suggested that students choose their own topics for research and that those topics relate to psychology subject matter or course material. Students' choices were limited by the parameters of the curriculum but they had a reasonable range of topics from science sub-fields. These suggestions were informed by Gardner (1983) who concluded that human cognition and the intelligence it manifests is grounded in a variety and range of "capacities" and "performances" and that different cultures value different types of intelligences. Developing a topic that is "relevant to the students' individual needs and interests" (Sticker, 2002, p. 309) is a creative technique when introducing students to primary scientific literature. "Creative projects in science courses provide memorable experiences, exceptional learning instruments, and opportunities for enhanced interest of the sciences" (Sticker, 2002, p. 308). Constructing and possessing new knowledge (Ashton-Warner, 1986; Dewey, 1933; Freire, 1993; Kelly, 1963) empowers the student as learning becomes personalized.

When a high school curriculum and culture is altered to accommodate more exposure to primary source science via real-life scientific experimentation and the ensuing studies, major obstacles are encountered such as lack of time, space, expertise, and equipment. Rigid schedules and ill-equipped science laboratories do not accommodate sophisticated experimentation. The high school science teacher's expertise is often that of a generalist rather than specialist. However, Einstein's concept of a "thought experiment" (Ireson, 2005) can be utilized to offset these obstacles. The exposure to real time science (Colburn, Henrique, Kisiel, Martin-Dunlop, & McMahon, 2005), through reading scientific studies becomes the basis for students' thought experiments as they consider their research topic. Exposure to real time science, in which students address their own research questions by examining real scientists' studies, motivates the students to grapple with the intellectual content of the scientific studies, to the best of their abilities, and to make sense of research responses (Dervin, 1999; Kuhlthau, 2004).

The real-time science research assignment was designed to provide individual workshop-style lessons on how to research and write a modified SLR. Employing Kuhlthau's (1991) model of the Information Search Process, reaffirmed in later years by the National Science Teachers Association's (2007) endorsement of an inquiry-based science curriculum, the lessons were tailored to the affective behavior of the high school students, their thoughts while researching, and their information seeking actions.

At each workshop in the SLR (Kuhlthau et al., 2007; Schmidt et al, 2008), librarians are interacting with the students to guide information searching and information handling, especially at three significant points: (1) selection of topic; (2) choosing and reading the peer reviewed studies; and (3) analyzing the research results. At the same time, students are providing librarians and teachers with feedback about the effectiveness of the lessons and about their own understanding of the materials they are studying. Sometimes the student informs librarians or teachers that the pace of workshops is too fast, or that the readings are too difficult to read, or that the analysis assignment is not clearly explained. With this feedback informing practice, students provide "evidence through self and peer evaluations, as well as teacher-student interactions" (Gordon, 2009, p. 58). At such times, a meeting is held between the collaborating science teacher and the librarian, adjustments in lessons are made, and due dates are altered. At other times, a tutorial is provided for students who need one-on-one help. Tutorials are administered continuously during the SLR. The practice and teaching of a modified scientific literature review, its pace and results, depend upon this continuum of evidence from students engaged in their research (Gordon, 2009).

Students receive guided inquiry instruction in Biology, Advanced Placement Biology, and Psychology. Chemistry and Physics students receive this kind of instruction as tutorials external to their classes. The 18 lessons are taught in approximately 15 minute segments of a 50 minute class session, with the remaining 35 minutes utilized as a workshop to begin the task to be taught. (See Appendix A for workshop descriptions). The Scientific Literature Review Curriculum was designed to meet five goals:

1. Introduce students to real time research in the pure and behavioral sciences.
2. Enable students to explore the scientific literature and experience the protocols of scientific study and writing.
3. Reduce the opportunities for plagiarism by including an analysis unique to each paper and requiring up-to-date-studies (within the last five years), unique to the student's interest.
4. Provide opportunities for a student to synthesize newly encountered information and develop original ideas about that information.
5. Provide opportunities for a student to get excited about scientific information and the work of scientists.

Students participating in the study are required to complete several research information tasks within a period of ten weeks of the 16-week semester. The tasks include:

1. Determine a topic and frame a question to research.
2. Investigate general press literature to discover what is being reported about the chosen research topic or question, and build background knowledge and vocabulary.
3. Write an introduction.

4. Search for, examine, and summarize six to eight peer-reviewed journal studies published within the last five years.
5. Write a methodology of research.
6. Write the results of the research.
7. Utilize six to eight study results to write an analysis of research which consists of comparisons between and among the studies, contrasts, trends, omissions, errors, and potential paths for new research.
8. Write a cover page with title and abstract.
9. Write a complete reference list in APA style containing all works used in the SLR.

Data Collection

Data were collected in four phases during and after the spring semester which extends from mid-January to mid-May. The first phase of data collection consisted of preliminary interviews in the week before students started their research. The second phase consisted of debriefing interviews after the papers were submitted. The third data set was collected from the content of the completed SLR papers. The fourth data set was collected two years later when 26 self-selected alumni, whose papers constituted 63% of the original sample, were interviewed about high-school to college transition issues.

Phase 1: Preliminary interviews with students before undertaking the project

Preliminary interviews were conducted with the entire sample of students in the days immediately following their receipt of the SLR assignment and prior to the students beginning their research. The 10 to 15 minute interviews took place in the library during class time. Fifty percent of the interviews were between the librarian and students who had chosen a topic. The other half were conducted by the librarian with the science teacher and students who were uncertain about their topics. Preliminary interviews were designed to assist the student in beginning the Information Search Process, with emphasis on choosing a topic. To achieve this, the undecided students located one or two general press articles that were interesting to them. The preliminary interview was unstructured, allowing for the exchange of questions and answers among the librarian, the science teacher and the student. During the interviews students' prior knowledge of and reasons for interest in potential topics were explored. Students were reminded that they would eventually frame the chosen topic with a research question.

Phase 2: Debriefing interviews with students immediately after completing final drafts

The final drafts ranged from four to 30 pages in length, with an average page count of 16 pages. Students submitted their papers and research files to the two librarians who graded them for quality of their research. The science teacher graded the SLR for science content. Each student was asked "How do you feel now?" and "What was your response to the process of the SLR?"

Phase 3: Content analysis of student SLR work

The students' papers were examined for topics chosen for study, completeness of the assigned task and for analytical thinking, i.e., whether comparisons and contrasts were made between or among studies, whether trends were detected, whether students noted omissions or errors in studies, and whether the direction for further research was indicated.. Analysis components were examined to indicate levels of independent synthesis of information and development of original ideas. Content was also examined to summatively assess the papers using letter grades.

Phase 4: Face-to-face interviews conducted 2 years after the SLR project

Face-to-face interviews with self-selected alumni from the original sample of the study were conducted two years later. These self-selected participants responded to a brief questionnaire they received in an email that explained the high school to college transition focus of the interviews. The librarian interviewed 26 students, or 63 percent of the original sample. This sample included 12 males and 14 females. Twenty-four of the responders were attending 22 Northeastern colleges and were interviewed on their college campuses. Two students were interviewed at a university in Arizona. The interviews did not explicitly address the SLR. All interviewees were questioned about their preparation for college level work and asked how their high school experience best prepared them for their college work. They were also asked about the advice they would give to high school administrators about preparing students for college. The six interview questions are listed below.

- How would you describe your transition from high-school to college?
- How did your high-school prepare you for college?
- What do you miss, if anything, about high-school that you wish you had now?
- What advice would you give high-school administrators about preparing high-school students for college?
- How prepared do you feel you are for the next three years of college?
- Do you have any other comments?

During these interviews unsolicited comments by alumni provided additional data about the long-term educational impact of the SLR.

Research Findings

The SLR project involved nine to twelve weeks of research and writing. Different information behaviors were exhibited at different points in the study: The Pre-Research The Research; and The Post-Research.

The Pre-Research

Students' responses to the preliminary interviews, to their choice of topics and content and to the completion of the project fall into three categories: emotional, intellectual, and social. (See Appendix B for a list of topic choices.) In preliminary interviews, although constrained by the subject field of the course (i.e., Biology, Chemistry, Physics, or Psychology), students chose topics for the following reasons: (1) Personal problems or issues with self, family, or friends provided emotional motivation and personal connection for the choice; (2) Intellectual curiosity motivated them to find answers to their questions; (3) Beliefs that they held that could make an impact on society and help people provided a social or humanitarian kind of motivation.

Forty-four percent of students chose topics motivated by emotion and personal connection. These topics included diabetes, adolescent drinking, steroid use, eating disorders, sports visualization, stress, and natural athletic ability. Forty-one percent of students chose topics motivated by intellectual interest. A common reason for choosing these kinds of topics was "I'm just interested in this." Topics garnering intellectual interest included: going green, abilities of birds, obesity, narcolepsy, quantum mechanics, cell phone dangers, quantum mechanics, schizophrenia, cell phone dangers, and human intelligence.

Fifteen percent of students indicated social reasons for their topic choices that they thought were potential problems or issues for society. These students were utilizing science to measure the social impact of an issue or society. The socially motivated topics included plague, academic dishonesty, avian flu, and teenage suicide.

The Research

The high school has a culture of research that supports the Grade 11 project. The introduction of the SLR unit was compatible with this culture. These students had completed research projects in their previous two years at the high school. Nevertheless, high anxiety (Kuhlthau, 1991) was the predominate behavior exhibited at initiation of the SLR, with 85% of the students of all capabilities indicating a concern about their own abilities to complete the assignment, the time it would take, and the effort they would have to make to complete the paper. During the process of researching and writing the Introduction to the paper the information behaviors exhibited were not noticeably different from those exhibited during other more traditional research projects. When students reached the stage of reading, reporting on, and analyzing the scientific studies, and interacting with peer-reviewed scientific text, their behaviors changed. They frequently expressed confusion and indecisiveness. Fifty percent of the students, after participating in the lesson, were able to understand the texts and take notes. The other 50 percent were not able to proceed. They required one-on-one assistance: the librarian as tutor read through the first scientific article with the student and helped him or her to take notes and summarize the article.

The Post-Research

After the paper was submitted, 78 percent of students expressed satisfaction to high-satisfaction with their work and "felt good" that the process was completed, ten percent had no comments about their work, and 12 percent expressed neutral comments such as "It's done." Those students whose responses were positive indicated that they now knew they "could do it." The librarians sensed feelings of accomplishment and empowerment as they observed students expressing satisfaction through body language, vocal tone, and facial expression.

Content Analysis of Student Papers

Evidence of knowledge construction was provided in content analysis of the students' SLRs. Researchers were particularly interested in quantifying the students' interactions with peer-reviewed scientific text. They wanted to measure the creation of new meanings in student's interpretations embedded in the results of their SLR research. Student analyses were scored by assigning one point for each instance of analysis. The unit of analysis was types of analytical thinking. Points were assigned for the following kinds of analyses drawn between or among scientific articles: comparing or contrasting; synthesizing research trends; detecting error or omissions; projecting recommendations for future research; creative or original thought about scientific content. This last type of original thought was defined as an "intellectual jump" in knowledge content. Table 2 displays the average points earned by students for each of the four letter grades.

Table 2 Assessment of SLR Papers

Letter Grade	Average points earned	No. of papers
A+	9.6	10
A	4.8	19
B	3.3	8
C/D	1.5	4

The average points earned (Column 2) indicate that even for the lower grades awarded, students were engaging in analytical thought and creating original thoughts about their research. Column 3 indicates the distribution of the letter grades, which indicates that students who received an A or A+ did so at a rate that was almost one and a half times greater than students who received a B, C, or D.

Criteria for construction of scientific knowledge included seven items that required students to:

1. State a clear definition of the research question.
2. Provide categories of research findings.
3. Compare studies.
4. Find exceptions
5. Find omissions.
6. Illustrate possible trends in the current research.
7. Predict future implications for research.

Students earned ten points for each of these criteria. A total of 70 points earned an A+. As an introductory assignment, the SLR was assessed for completion of assignment, not for comprehensive mastery of the topic.

Enthusiasm for the SLR was indicated by students' interpretations of their own research and their unabashed submissions for research prizes. The following comments from post-research debriefing interviews indicate their enthusiasm:

"I did it!"
"It wasn't as bad as I thought."
"I learned a lot."
"I feel great!"

Findings of Face-to-Face Interviews

These interviews, conducted two years after the completion of the SLR papers with 26 self-selected students took place on the campuses of the colleges they were attending. The interviews contained six questions about high-school to college transition. None of the questions specifically referenced the writing and research program at their former high school or the SLR assignment. However, at three different points during the interviews several students referred to the impact of the SLR, as follows.

Question # 2 of the interview: *How did your high school prepare you for college?* The prompt for this question, if there was not a quick response, was: *What was the most helpful preparation?* Thirty percent of the responses were "research program," the "research paper," or "the junior (Grade 11) research paper." These students indicated significant appreciation for that preparation. One student said, "The most helpful was definitely the Junior Science Research Paper."

Question # 4: *What advice would you give your high school leadership about preparing high school students for college?* Fifteen percent of students responded that research and writing should be emphasized by the high school administration. One student said, "Just simply encourage the research. We do a lot of research here at Lafayette."

Question # 6: *Do you have any other comments?* Two of 26 responses, or 8 percent of students who responded, added enthusiastic comments about research.

> No one is watching over you. You have all of this freedom. I felt ready academically and socially and nothing went haywire. My research paper for freshman writing seminar was painless. I did it on Inuit people and their education. I had to use a lot of peer review articles. We had a library session before the assignment but I had already been there, done that. Used (my high school) logins and passwords for databases and asked my mom to send them to me.
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> I go to the library for studying – that is the best! Research papers in high school definitely helped and I haven't met a lot of people who put in as much time as we did in high school learning how to do research.

Implications for Research and Practice

The SLR study points to the need for more research on the modified SLR model for inquiry projects situated in the school library. How can this model be adapted for larger school populations and younger students? How can knowledge development be tracked after students complete the SLR? Are students who experience the SLR model of scientific inquiry more likely to choose collegiate science majors?

Other research questions focus on the use of primary literature with young researchers. Can the use of primary literature be practiced in other disciplines? What are the consequences for how information literacy is defined? What are the information skills specific to science? What are the multiple models of information literacy that correspond to the way various disciplines engage in research to discover new knowledge?

The use of the modified SLR method has implications for practitioners as well. The findings of the SLR study are consistent with other research on primary literature. There is evidence that introducing science students to primary literature and the SLR process promotes a deepening of understanding of science and encourages the construction of new knowledge. Evidence indicates that this kind of engagement can heighten a student's long-term interest in the sciences (Hoskins & Stevens, 2007; Sticker, 2002; Tribe & Cooper, 2008).

Incorporating primary literature, in the form of scientific studies, as part of an education in the sciences is strongly indicated for practitioners. Through stimulating interests in the sciences, allowing for synthesis of information and the development of new knowledge, the SLR holds the potential for students to become excited about the sciences, engaged in scientific research, opening doors for the possibility that they will seek careers in the sciences. The use of primary literature results in a stimulating learning experience for the science student. Adapting this approach to other (non-science) disciplines might allow for a similar experience (Personal Correspondence, 2008; 2010).

When content-driven science curriculum shares class time with a process oriented curriculum of scientific inquiry, when students are searching and reviewing current existing studies about a chosen topic, they have opportunities to gain content knowledge and formulate their own new knowledge (Gordon, 2001). The Information Search Process (Kuhlthau, 1991) shares the stage with content coverage and yields a deeper understanding of current scientific content. Science teachers and library teachers shift their roles from being caretakers of pre-existing knowledge and providers of access to information to being guides for the student (Kuhlthau, 1995) in building new, original knowledge (Elrod, 2007; Gordon, 2001, 2009; Hoskins & Stevens, 2007; Tribe & Cooper, 2008).

The role of the student also changes, from building a knowledge bank of existing information to achieving a personal understanding that fosters new ways of thinking about science and doing science. Through the use of evidence-based practices (Gordon 2009; Todd 2001, 2004) in which teachers, librarians and students determine, assess, and alter pedagogical approaches, student-centered inquiry-based science research projects involve concrete examples of real and deep knowledge development.

> Student learning outcomes … corroborated that when librarians' bibliographic strengths are paired with [a science teacher's] disciplinary expertise, students enjoy enriched learning experiences as they practice framing appropriate questions, selecting authoritative resources, and interpreting and applying richly textured insights." (Elrod, 2007, p. 14)

The new environment of inquiry-based project curriculum and collaborative educational efforts provides today's teaching librarian with an opportunity to work with science teachers to enhance the information handling skills of students and to promote original scientific thought. While the process itself is not easy, this curriculum is part of a new reality–a new kind of schooling that catches the imagination and enthusiasm of students and brings them into the new age of scientific inquiry. High school students are guided by librarians and science teachers into a collegiate level of scientific inquiry and knowledge creation as the SLR "enable[s] librarians [to] assume a more central role in the … educational mission" (Elrod, 2007, p. 4).

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Appendix A
Workshop Descriptions

Workshop	***Essential Questions***	***Goal/Task of Workshop***
1 Benefits of a Scientific Literature Review	-How is scientific knowledge developed, shared, evaluated and communicated? - How does the scientific method apply to my "mind on" science research investigation?	-Understand and discuss the scientific method and the role of the scientific literature review (SLR) in the world of science. -Examine an example of a published scientific study.
2 The Student's Assignment Begins	-What is a scientific literature review? -How does it relate to my personal investigation with a science discipline?	-Review the purpose, attributes, and process of a scientific literature review. -Apply the concept of scientific inquiry to student's personal scientific interests and/or questions.
3 Making it Meaningful: Browsing Databases	-What is the difference between a search engine and database? -How do I conduct my search?	-Understand and compare the definition of a database and search engine and the database's role in information gathering. -Choose appropriate databases for research and research topic through browsing
4 Creating and Organizing the Research Folder	-How can I keep all my information organized? -How do these organizational skills relate to assignment concerns such as plagiarism, meeting requirements, and quality of results?	-Understand what information must be collected for this project. -Access, record, and organize needed information, including bibliographic records, articles, personal notes, and project handouts and worksheets.
5 Researching the Introduction	-What is information authority? Is there more than one type or level? -How does the general press reflect/report science knowledge?	-Distinguish between general press information sources and peer reviewed information sources. -Locate two articles or other items on the topic from general press sources.
6 How to Read and Take Notes from a General Press Article	-What information is interesting or important to me within an article? -How can I summarize information that is relevant to my interests?	-Read a general press article and identify information the student thinks is important, relevant and interesting. -Select interesting fact, figure, etc., to create a "hook." -Compose an article summary of one or two paragraphs in student's own words after reading the article.
7 How to Write the Introduction	-How can I make sense of all the information I have located? -How can I best introduce my scientific research topic? -How do I use my summaries to write my introduction?	-Organize and arrange general press article summaries. -Select a "hook" for the research paper introduction. -Write the introduction.

Appendix A (continued)
Workshop Descriptions

Workshop	*Essential Questions*	*Goal/Task of Workshop*
8 Searching for Peer Reviewed Studies	-What is a peer reviewed journal study? -What does a study look like?	-Distinguish between general press information and peer review information sources and then construct an advanced search query using specialized search terms and limiters. -Locate two to six articles on the topic from peer review sources and print these.
9 How to Read and Take Notes from a Peer Reviewed Journal Study	-How can I read a study and summarize information with factual and descriptive details? -How do I use my notes and summaries for the text of my scientific literature review (SLR)?	-Read a peer reviewed journal study and locate information that answers six key research questions about the study. -Compose a summary using student's own words based upon these six key research questions.
10 How to Write the Methodology	-How can I write the Methodology?	-Apply methodology reporting to student's research and compose the methodology section of his research paper.
11 How to Write the Results of Research	-What is the purpose of the Results of Research section of a science research paper? -How can I organize and effectively present my research?	-Understand the purpose of a Results of Research section in scholarly scientific papers. -Organize and arrange peer reviewed journal summaries as a preliminary step to writing the Results of Research section.
12 How to Use and Create a Table, Chart, or Graph for the Research	-What is the purpose of a chart, table, or graph in a scientific paper? -How can I create a table, chart, or graph and what elements do I include to illustrate my finding?	-Understand and discuss the purpose and use of tables, charts, and graphs in a paper. -Create a table, chart, or graph which emphasizes key finding(s).
13 How to Write the Analysis of Research	-What is the purpose of the Analysis of Research section in a scholarly scientific study? -How can I compare, contrast the six studies and effectively develop my Analysis section?	-Understand the purpose of an Analysis of Research section in a scholarly scientific study. -Evaluate, compare peer reviewed journal study studies and write the Analysis of Research section.
14 How to Write the Conclusion	-Why is a Conclusion necessary in a scholarly scientific study? -How do I write a Conclusion?	-Understand and discuss the purpose of a Conclusion in scholarly papers. -Compose the Conclusion section.

Appendix A (continued)
Workshop Descriptions

Workshop	Essential Questions	Goal/Task of Workshop
15 How to Write the Abstract	-What is an Abstract and what is its purpose? -How can I write an Abstract for my research paper?	-Understand and discuss the purpose of Abstract in scholarly studies. -Create a list of key subject terms that relate to the research topic and compose the Abstract section.
16 How to Write the Reference List	-What is the role of a Reference List in scientific writing? -How should I organize my references?	-Understand and discuss the purpose of a Reference List in scholarly studies. Understand the specific formation for (APA) style -Create a Reference List in APA style.
17 Creating a Title and Completing the Cover Page	-What is the purpose of a Title for a scientific research paper? -How can I write a clear and concise Title for my scientific literature review (SLR)? -What should it look like?	-Understand and discuss the purpose of a Title of a scientific paper or journal study. -Compose a Title for his paper that contains appropriate keywords and utilizes formal language.
18 Putting it All Together to Turn the Scientific Literature Review In to the Teacher	-Why is it important to organize the Research Folder in a specific format? -How exactly is the Research Folder organized?	-Understand the necessity of organizing his Research Folder properly. -Organizing the Research Folder with all handouts, annotated general press and peer reviewed scientific studies, as well as, the corrected version of the first draft and copies of the final paper.

Appendix B
Sample Junior Research Paper Topics - Courses 2007-2009

Course(s)	Topic	Year
AP Bio	Nanotechnology and Cancer Treatment	2007
AP Bio	Celiac Disease: Its Nature and Treatment	2007
AP Bio	The Genetic Basis of Schizophrenia	2007
AP Bio	Genetic Engineering: Meeting the Agricultural Needs of the Future	2007
AP Bio	Narcolepsy	2007
AP Bio	Congenital Heart Disease	2007
AP Bio	Influences on Cognitive Function	2007
AP Bio	Clinical Depression: Genetic and Environmental Roots…	2008
AP Bio	Genetic Predisposition to Cancer & Future Impact of Genetics …	2008
AP Bio	String Theory	2008

Appendix B (continued)
Sample Junior Research Paper Topics - Courses 2007-2009

AP Bio	Efficacy and Pharmacological Uses of the Placebo Effect	2009
AP Bio	Genetically Modified Crops	2009
AP Bio	Moral, Political, and Religious Issues … Stem-Cell Research	2009
AP Bio	Side Effects, Treatments .... for Type 1 Diabetes	2009
AP Bio	Finding the Etiology of Autism Spectrum Disorder …	2009
AP Bio	Crohn's Disease	2009
AP Bio	Benefits of Strength Training for Different Injuries ..	2009
AP Bio	Eating Disorders and Type 1 Diabetes Correlation	2009
AP Bio	Cause and Prevention of Alzheimer's Disease …	2009
AP Bio	The Role of microRNAs in Cancer	2009
AP Bio	Fibromyalgia Causes and Therapies	2009
AP Bio	Synesthesia	2009
AP Chem	Cosmetic Surgery	2008
AP Chem	Anthrax: Causes, Effects, Treatment	2008
AP Chem Psy	Brain Chemistry and the Perception of Homosexuality	2007
AP ES	Relationship … Global Warming and Environmental Impact	2009
Bio	Adolescent Pregnancy	2007
Bio	The Causes and Effects of Postpartum Depression	2007
Bio	The Causes and Effects of Homelessness in America	2007
Bio	Childhood and Adolescent Depression	2007
Bio	Phenyketonuria, the Diet and How It Affects the Brain	2007
Bio	Evolutionary Link Between Birds and Dinosaurs	2007
Bio	Effects and Treatment for Insomnia	2007
Bio	Gene Silencing	2007
Bio	Effects of Hormone Therapy Upon Women	2007
Bio	Steroid Usage	2007
Bio	Leukemia	2007
Bio	Snakes and Snake Venom	2008
Bio	Cognitive Development	2008
Bio	Teenagers and Steroid Use	2008
Bio	Music Therapy:A Review of Current Literature	2008
Bio	Cloning	2008
Bio	Teenage Alcoholism	2008
Bio	Celiac Disease	2008
Bio	Vegetarianism	2008
Bio	Health Effects of Popular Diets and Weight-loss Methods	2008
Bio	The Heritability of Intelligence	2008
Bio	Enviroment and Its Effect on Child Development	2008
Bio	Analysis of Happiness and Life Satisfaction	2008
Bio	Genetic Disorders and the Amish	2008

Appendix B (continued)
Sample Junior Research Paper Topics - Courses 2007-2009

Bio	Global Warming and Climate Change	2008
Bio	The Media's Effect on the Teenage Brain	2008
Bio	Alcholism's Genetic Influences	2008
Bio	Concussions, Their Causes and Effect Amongst Athletes …	2008
Bio	The Effect of Music on the Brain …	2009
Bio	Causes of Precocious Puberty	2009
Bio	Bacterial Meningitis	2009
Bio	The Benefit of Meditation and its Many Applications	2009
Bio	Nuclear Fusion	2009
Psych	The Psychological Effects of Child Abuse	2007
Psych	Body Dysmorphic Disorder	2007
Psych	Social Anxiety Disorder	2007
Psych	Time Perceptions and Circadian Clocks	2007
Psych	Post Tramatic Stress Disorder	2007
Psych	Brain Plasticity	2008
Psych	Postpartum Depresssion	2008
Psych, AP Bio	Personality: Nature vs. Nurture	2008
Psych, AP Bio	Bipolar disorder: Diagnosis, Treatments, and Consequences	2008
Psych, AP Bio	Causes of Teenage Suicide	2008
Psych, AP Bio	Etiology and Biological Effects of Homosexuality	2008
Psych, AP Bio	The Effects of Birth Order on Personality	2009
Psych, AP Bio	Complementary and Alternative Medicine	2009
Psych, AP Bio	The Genetic and Environmental Factors of Intelligence	2009
Psych, AP Bio	Physiological and Behavioral Aspects of the Honeybee Colony	2009
Psych, AP Bio	Bipolar Disorder Risk Factors	2009
Psych, Bio	The Relationship Between Creativity and Mental Illness	2007
Psych, Bio	The Nature and Causes of Nightmares	2007
Psych, Bio	Pediatric Bipolar Disorder	2007
Psych, Bio	Research and Uses of Stem Cells	2007
Psych, Bio	Animal Cognition	2007
Psych, Bio	The Nature and Effects of Humor	2007
Psych, Bio	Obsessive-Compulsive Disorder	2007
Psych, Bio	Narcissism	2007
Psych, Bio	Animal Intelligence and Cognition	2007
Psych, Bio	Munchausen Syndrome	2007
Psych, Bio	The Effects of Antidepressants on the Body and Mind	2007
Psych, Bio	The Nature of Human Attraction	2007
Psych, Bio	Effects of Animals on People	2008
Psych, Bio	Psychological Effects of Color	2008