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Changing the Scholarly Sources Landscape with Geomorphology Undergraduate Students

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Abstract

Science is a core discipline in academia yet the focus of most undergraduate technical writing is generally on the data and results, not the literature review. The Science, Technology, Engineering, and Math (STEM) librarian and a new geology professor at the University of Nebraska at Omaha (UNO) collaborated to develop an information literacy session for students in a geomorphology class. Here we outline the background of the campus STEM initiatives and the assignment as well as the library instruction activity, learning outcomes, and assessment components. The activity improved student use of scholarly sources and we provide suggested activity modifications for future teaching and assessment efforts.

Introduction

Although writing is vital to scientific literacy, few undergraduate science courses focus on the importance of reviewing the scientific literature. Most courses emphasize the guidelines on how to properly report and analyze data but often give little instruction on how to prepare a literature review; building on the literature is often an afterthought (McMenamin 2006). As future professionals, students need to learn about the preferred sources in their discipline, how information is disseminated, barriers to retrieval (abstract-only, using interlibrary loan), and expectations of the types of sources required.

When geomorphology students submitted term paper sources at the beginning of the semester that were mainly comprised of Wikipedia articles, corporate web sites, and personal travel blogs, a new Science, Technology, Engineering, and Math (STEM) librarian and new geology professor at the University of Nebraska at Omaha (UNO) collaborated to develop an information literacy session. The class was comprised of third- and fourth-year students aiming to build critical thinking and evaluation skills. Students needed assistance knowing what types of information they were looking for, finding discipline-specific information, and evaluating the scholarly value of trade magazines and journals.

In this paper, we introduce the UNO campus STEM initiatives and the classroom assignment. We also provide a brief review of the ACRL Standards for Science and Engineering/Technology and a summary of the geoscience and library science literature, especially focusing on geology. Data presented from before and after the library instruction shows student growth from browsing Wikipedia for first drafts to using scholarly sources in the final paper. The library instruction activity, learning outcomes, and assessment components are included along with conclusions and modifications for future teaching and assessment efforts.

Background

STEM Initiatives at UNO

The University of Nebraska at Omaha (UNO) is Nebraska's only metropolitan university and classified as a Carnegie Doctoral/Research University (DRU). The student body is comprised of approximately 12,400 undergraduate and 3,000 graduate students, with 2,061 international students and 1,479 military and veteran students. Approximately 50% of UNO's students are first-generation college attendees. In 2013, UNO created a STEM Strategic Plan focusing on STEM education, or STEM learning, as a metropolitan campus priority (University of Nebraska 2014). The strategic plan concluded that focusing directly on STEM learning would accomplish the full spectrum of STEM interests at UNO. UNO STEM scientific research elements included strengthening the preschool through college STEM pipeline and developing a more effective STEM learning environment. An improved STEM learning environment will provide increased opportunities for engaging STEM undergraduates, graduates, and community partners in teaching, research, and service, thereby facilitating the broader impacts of STEM for the metropolitan area, state, and nation. There are four goal areas within this strategic plan: 1) teaching/learning, 2) research, 3) service/community engagement, and 4) STEM infrastructure. Within Goal 1, our in-class collaboration aligned with Objective 1.4: "Support new or enhanced courses that innovatively engage students in STEM concepts; Aligning with campus and faculty interests in new STEM coursework, particularly at introductory levels, support faculty collaboration, and the development of innovative STEM coursework" (University of Nebraska 2014). Within Goal 2, our project aligned with Objective 2.1.: "Support active learning strategies for STEM content" (University of Nebraska 2014).

Teaching Geomorphology to Undergraduates

Geomorphology is the study of the processes that shape the Earth and the landforms produced by these processes. The goal of the Process Geomorphology (GEOL/GEOG 4330/GEOG 8266) course at UNO is for students to gain content knowledge of landform types and processes and develop critical thinking skills to interpret past, present, and future landscapes on Earth and other planetary bodies. In addition, the course aims to develop writing and analytical skills through a term paper assignment where students evaluate the geomorphic history of a landscape through time using evidence from peer-reviewed literature. Process Geomorphology is an optional upper level course for the Geology, Geography, and Environmental Studies degrees at UNO. The course is also cross-listed as an elective graduate course (GEOG 8336) for the Master of Arts Geography degree.

In the fall semester of 2014, the course consisted of 18 students, including 16 undergraduates (11 seniors and five juniors) and two geography graduate students. Undergraduate students included six geology majors, nine environmental studies majors, and one geography major. Seventeen students completed the course and 15 completed all writing assignments. Most students had completed the majority of their geology or environmental studies courses prior to enrolling in the Geomorphology course and were within one to two years of graduation. All students had also completed the university-wide general education writing requirements of English Composition I and II. An additional writing intensive course is required within the students' major; for geology, the senior thesis capstone course fulfills this requirement. At the time of the course, none of the undergraduate students had completed their discipline-specific intensive writing course. Due to the metropolitan setting of the university, which attracts a range of traditional, transfer, and returning students, students in this course had a wide range of information literacy skills and may or may not have had any formal training in how to use the library. There is no required course at UNO that prepares all geoscience students to conduct library research.

The assignment included completing a six- to eight-page paper focused on the geomorphic history of a location of a student's choice. The main task was to research the site in detail to address the question, "What are the processes that shaped this landscape over time to produce the features we observe today?" The objective was to use scholarly sources to build an interesting story with a central thesis statement about how the landscape formed. Through this process, students would not only learn about geomorphic processes and landscape evolution at their site, but also gain experience organizing ideas around a central concept and using the scientific literature to support their ideas. Guidelines included considering a location with several distinct landforms to maximize the ability to locate relevant literature. Student topics encompassed several popular destinations, such as Yosemite, Yellowstone, Zion, and Arches National Parks, as well as the more exotic locations of Mesopotamia and Mars.

Students submitted three drafts of the paper prior to a final draft. They were given detailed feedback on content, format, and writing style after each draft submission. The paper constituted 40% of the overall grade in the course, divided among a topic paper, two drafts, and the final paper for a total of four assignments with due dates spaced approximately three weeks apart. The expectations for each draft increased and students were provided a grading rubric outlining the components of an expert, advanced, and novice paper with respect to content, writing style, and references (Appendix 1). For each draft, expert papers included at least 80% of the expected outcomes, advanced papers included 50-80% of the expected outcomes, and novice papers contained less than 50% of the expected outcomes. The overall goal was to have 80% of students fall into the Expert or Advanced categories for each draft.

Linking to ACRL Standards for Science and Technology/Engineering

The UNO Criss Library is a member of the Association of College and Research Libraries (ACRL). ACRL, the American Library Association (ALA), and the Science and Technology Section (STS) Task Force on Information Literacy created the Information Literacy Standards for Science and Engineering/Technology in 2006 (Information Literacy 2006). The Information Literacy Standards broadly outlined the need for specific information literacy skills in the STEM fields:

> Science, engineering, and technology disciplines pose unique challenges in identifying, evaluating, acquiring, and using information. Peer reviewed articles are generally published in more costly journals and, therefore, not always available. Gray literature requires knowledge of the agency/organization publishing the information. Much of science, engineering, and technology is now interdisciplinary and, therefore, requires knowledge of information resources in more than one discipline. Information can be in various formats (e.g., multimedia, database, web site, data set, patent, Geographic Information System, 3-D technology, open file report, audio/visual, book, graph, map) and, therefore, may often require manipulation and a working knowledge of specialized software. Science, engineering, and technology disciplines require that students demonstrate competency not only in written assignments and research papers but also in unique areas such as experimentation, laboratory research, and mechanical drawing (Information Literacy 2006).

The geology professor and STEM librarian focused on assessing students for ACRL Standards One and Four and subsequent performance indicators. In Standard One, the information literate student determines the nature and extent of the information needed (Information Literacy 2006). The first assignment submitted was a topic paper, where students started gathering ideas, including the location of choice, at least three landscape features, eight to ten facts about their site and at least five scholarly resources. The assignment assessment matched the expectations of the ACRL Standard One, Learning Performance Indicator One outcomes (Information Literacy 2006) that include the following student skills:

1. Identifies and/or paraphrases a research topic, or other information need such as that resulting from an assigned lab exercise or project.
2. Consults with instructor/advisor for appropriateness of topic, research project, or laboratory exercise question.
3. Develops a hypothesis or thesis statement and formulates questions based on the information need.

4. Explores general information sources to increase familiarity with current knowledge of the topic.
5. Defines or modifies the information need to achieve a manageable focus.
6. Identifies key concepts and terms that describe the information need.

Performance Indicator Two states that the information literate student identifies a variety of types and formats of potential sources for information (Information Literacy 2006). The outcome for Performance Indicator Two was emphasized: "Identifies the purpose and audience of potential resources (e.g., popular vs. scholarly, current vs. historical, external vs. internal, primary vs. secondary vs. tertiary)" (Information Literacy 2006).

At the time of the creation of the assignment and rubrics (2014), ACRL had just introduced the first draft of the Framework for Information Literacy in Higher Education (ACRL 2015). Filed by the ACRL Board of Directors in February 2015, the document replaces the Standards for Information Literacy in Higher Education. The Standards outline competencies, skills, and outcomes students must achieve to become information literate. The new Framework is organized around six frames; each centered on a "threshold concept" designated an integral component of information literacy (Oakleaf 2014). In addition to a threshold concept, each frame also includes "knowledge practice/abilities" and "dispositions" associated with that threshold concept, but neither is intended to be used as learning outcomes (Oakleaf 2014). We began our outcomes-based research before the Framework was adopted but our work fits the knowledge practices as outlined in the Searching as Strategic Exploration concept of the Framework.

The second assignment included two to four pages of text with the goal of getting words and ideas onto paper, including ten scholarly sources. Specific details, such as a description of the location, a thesis statement that frames the paper topic, a description of the geologic history of the site, and the main geomorphic features observed at the site were included in this draft (largely in sentence format, but incomplete paragraphs or ideas were acceptable). Assessment of draft one also included an evaluation of whether or not ideas were organized around a main theme and the quality of supporting sources.

The third assignment, or second draft of the paper, included four to six pages of text where students were to focus on constructing their story with clear ideas and at least 15 scholarly sources. In addition to expanding on the requirements listed in draft one, students described the geomorphic processes that created the landscape features and used supporting evidence from scholarly resources. At least 15 scholarly sources appropriate to their topic of choice were required in the references list and in the text. Here, the assessment included ACRL Standard Four, which states that the information literate student understands the economic, ethical, legal, and social issues surrounding the use of information and its technologies and either as an individual or as a member of a group, uses information effectively, ethically, and legally to accomplish a specific purpose (Information Literacy 2006). The emphasis of this draft was using supporting information from at least fifteen different scholarly sources to communicate a clear explanation of the geomorphic processes at work. The ideal outcome included excellent organization of the story around a main thesis with interesting and polished sentences.

Skills emphasized in the final draft, or fourth assignment, matched the standard learning outcomes, including "Selects an appropriate documentation style for each research project and uses it consistently to cite sources" and "Selects, analyzes, organizes, summarizes, and/or synthesizes information from a variety of resources" (Information Literacy 2006). For the final draft, students were to produce a polished six to eight page paper with at least 15 scholarly references that communicated an interesting story focused on the processes that shaped their landscape of choice. Building from the second draft, an expert paper included clear explanations and insights into the processes that shaped their landscape based on supporting evidence from their scholarly sources. Expert papers were well organized, written with interesting sentences and few grammar or spelling errors, and included figures or photographs supporting the ideas presented in the paper.

Literature Review

The majority of the library literature studies focus on English and public speaking courses while very few studies focus on reaching out to geoscience students. In a literature review of both library science and geology disciplines, the authors found little research connecting geomorphology, university students, and information literacy or classroom instruction.

While there is ample historical literature on teaching information literacy or bibliographic instruction (Lupton 2008), a review of the library literature shows three common themes in the smaller pool of science-related information literacy articles: 1) short, practical pieces highlighting a new resource; 2) case studies describing product-specific classroom activities for science majors; and 3) case studies focusing on information literacy competencies for all science majors. The literature has plenty of examples of short, practical articles that give the reader an overview of a new resource (most often an electronic resource) and how to share that resource with patrons and teach them to use it (Brodie 1991; Locknar et al. 1997). There are also examples of how to target the STEM departments on campus to share specific resources. For example, Martorana and Meszaros (1997) provide ideas on holding library workshops for physical sciences and engineering departments and separate ones for environmental and life sciences. Davis et al. (1994) discuss how to provide geoscience-writing workshops to address curriculum needs and cut down on repetitive patron questions. Blake (2014) addresses the volume of scholarly information available to science students and how it serves as a barrier to access.

Case studies are popular in the library literature. They share information literacy classroom activities for science classes (Gill & Burke 1999; Kobzina 2010; Moniz et al. 2010) through one-shot sessions (Jacklin & Bordanaro 2008; Waller & Knight 2012; Ferrer-Vincent 2013), embedded librarians (Ochola & Peterson-Lugo 2003; Larsen 2005; Pritchard 2010; Blake & Warner 2011) or entire bibliographic instruction courses/programs (Nelson 1991; Schloman & Feldmann 1993; Jacobson & Xu 2004).

There were a few case studies calling for the creation of information literacy standards for all science majors (Manuel 2004; Scaramozzino 2010) or across discipline-specific curricula (Kutner 2000; Russo et al. 2008; Bent & Stockdale

2009; Berman et al. 2011). However, Yocum and Almy (1999) searched library literature and geoscience society web sites, and performed telephone interviews with other geoscience librarians but were unsuccessful in identifying model programs or information competencies for the geosciences.

There have been a few recent articles focusing on geoscience courses (Fescemyer 2000), but they do not focus on the ACRL Standards for Science and Technology. For example, Dechambeau and Sasowsky (2003) discuss using information literacy standards to improve geoscience courses and mapping assignments to the 2000 ACRL Information Literacy Standards for Higher education outcomes. They note most geoscience courses include work that implicitly address some information literacy issues but that it should be explicitly included as part of the curriculum (Dechambeau & Sasowsky 2003). Kimsey and Cameron (2005) provide a computer-based Information Literacy Test for Geography Majors, composed of 48 multiple-choice questions to measure information literacy in undergraduates based on the ACRL standards. Price (2010) discusses using class discussions, small-group approaches, and peer-assisted learning to discuss examples of effective and poor use of literature in research reports to help students effectively place their research in the context of the existing literature but does not link to the standards specifically.

In 2006, the ACRL published the latest revision of the Information Literacy Standards for Science and Engineering/Technology to guide practitioners in the creation of their information literacy programs. Jurecki and Wander (2012) criticize these standards as being derivative of social science standards and disconnected from "the way in which scientists actually evaluate literature" (p. 102). They provide a two-tier set of criteria for evaluating scientific literature that can be used in traditional and nontraditional learning environments for students of all majors (Jurecki & Wander 2012). It remains unclear how librarians will use the new Framework to teach information literacy concepts in the science and technology disciplines, and whether they will branch out with their own Framework as they did with the Standards (2006).

The majority of published studies have focused on describing new resources, using case studies to highlight different approaches to incorporating information literacy into the classroom, and the creation of information literacy standards. This work fills a gap in the existing literature by specifically focusing on information literacy in a geology classroom and more specifically a geomorphology course.

Methods

We obtained permission to conduct this study from UNO's Office of Sponsored Programs and Research (SPR). The study was determined to be of low risk to the human subjects because data was collected as part of normal educational practices and in a manner such that identifying information on students was not reported (therefore not putting them at undue risk). We used a rubric to assess student sources at the four different stages of writing, including the topic paper, the first draft, the second draft, and the final draft. Students had the option to turn in a second draft of the final draft but few accepted this offer and these drafts were not included in the citation analysis.

Three weeks into the semester, the class participated in an active learning discussion called "Scholarly or Not," which required students to evaluate a source for appropriateness and identify characteristics of a "good" source for this particular assignment. The STEM librarian had a series of slides with screen shots to serve as prompts. The first slide included popular tabloid cover, purposefully selected to ease students into the activity by providing low-hanging fruit to clarify the purpose of the activity. It provided humor, putting students at ease so they would be comfortable enough to contribute to the discussion of scholarly sources. The STEM librarian then presented a variety of additional source examples from easy-to-spot children's literature to encyclopedias and self-published books that were difficult to assess by simply looking at the cover. Screenshots of peer-reviewed items from the ProQuest GeoRef database were also included so students would know how to look for indicators of online scholarly sources that only provided citations or abstracts. After each slide, there was discussion of when and where this source might be appropriate for information, depending on the context. For example, students discussed the difference between using a tabloid for a source in a paper regarding commercial media and using it as a source in a geomorphology paper. It would be fine in a media assignment but it would not be an authoritative scientific source for this course.

The activity concluded with a student volunteer showing how to locate information through the UNO library web site. This provided students with a relevant example of the search process, helping familiarize the process of how to retrieve sources, especially if a journal article was only available through interlibrary loan. The STEM librarian provided students a summary of relevant contact information and suggested sources to initiate their information search. Throughout the semester, students were frequently encouraged to visit with the STEM librarian to address challenges in finding appropriate sources, correctly formatting citations, and crediting sources. The STEM librarian held weekly office hours in the same building immediately following the geomorphology course meeting time throughout the semester.

At the end of the semester, the geology professor collected copies of all the assignments and met with the STEM librarian to finalize the assessments. One student who completed the initial topic paper assignment dropped the course prior to the collection of subsequent drafts and this student was not included in the overall study. The STEM librarian and professor independently assessed each student paper using the rubric in Table 1 to count the number of students who achieved the goals of the expert, advanced, or novice categories with respect to properly finding and citing scholarly sources in the references section. Following each individual assessment, scores were averaged together to create the final scores reported in the expert, advanced, and novice categories (Table 1). At the beginning of the semester, students were provided a written narrative of the paper objectives (Appendix 1) as well as a grading rubric (Appendix 2) for the overall paper. The more detailed rubric assessed overall paper grades for the course, which included aspects of content and writing style in addition to the use of scholarly sources both in the references section and in the text (Appendix 2).

Results

Overall students showed marked improvement in their ability to identify and use scholarly sources following the "Scholarly or Not" classroom activity (Table 2). After the initial assignment, it was clear that many students were not familiar or comfortable with the process of identifying and searching for scholarly sources, especially when sources were not immediately available through a general Internet search. Students responded well to the intervention activity and subsequent drafts showed improvement in the overall quality of sources (Table 3). Some students continued to struggle with finding appropriate sources but did not seek out additional help from the STEM librarian. Ultimately, over 80% of the students referenced scholarly sources by the end of the four-part assignment, achieving the performance goal.

Topic Paper

Sixteen topic papers were collected and the assignment parameters asked for five sources, with a maximum of three book sources. Scholarly sources included those from peer-reviewed journals or non-independently published books. There were 77 sources used, leading to an average of 4.8 sources per student. Scholarly journals accounted for only 45% of the sources, followed by nearly 20% web sites. These web sites included educational, commercial, and non-profit web sites. Government web sites, including the United States Geological Survey, United States Department of the Interior, and United States National Park Service, counted as an independent source and made up 18% of the sources. Books constituted a mere 13% of the sources and 8% of the sources were unknown due to incomplete citation information.

Draft One

Sixteen first drafts were collected and the assignment parameters asked for ten scholarly sources. One hundred and fifty-six sources were used, leading to an average of 9.75 sources per student. Scholarly journals rose to 62% of the sources, followed by a drop in the use of web sites to 11%. These web sites included educational, commercial, and non-profit web sites. Government web sites, including the United States Geological Survey, United States Department of the Interior, and United States National Park Service, constituted just 13% of the sources. Books were 10% of the sources and unknown sources dropped to 3% as students learned to complete citations.

Draft Two

The second draft requested students use at least 15 scholarly sources and 15 assignments were collected (one student dropped the course prior to completion of the second draft). The second drafts included 217 sources, leading to an average of 14.46 sources per student, a slight decrease from the previous assignment average. Scholarly journals rose again to 69% of the sources, followed by another drop in use of web sites to just 5%. These web sites included educational, commercial, and non-profit web sites. Government web sites remained at 13% of the sources. Books dropped slightly to 9% of the total sources and unknown sources stayed constant at 3%. In this draft, students began using theses and dissertations, which made up 1% of the sources.

Final Draft

Fourteen final drafts were collected (one student never turned in a final draft) and the assignment parameters requested 15 scholarly sources. There were 207 sources used, leading to an average of 14.76 sources per student and a slight increase in the average number of sources per student. Scholarly journal use dropped slightly to 66% of the sources and web sites stayed steady at 5%. These web sites included educational, commercial, and non-profit web sites. Government web sites remained 13% of the sources. Books rose slightly to 10% of the sources and unknown sources rose slightly to 4%. Theses and dissertations made up 2% of the sources.

Overall Class Scores

A total of 16 topic papers, 16 first drafts, 15 second drafts, and 14 final papers were placed into the expert, advanced, or novice category of the rubric for their use of scholarly sources (Table 1). For the topic paper, the class average was 65.5% of students falling in the Expert or Advanced category. In the first draft, 80% of students fell into the Expert or Advanced category. On the second draft, only 70% of students fell in the Expert or Advanced category whereas 85.7% of students met the requirements for the Expert or Advanced category in the final paper.

Discussion

The course instructor observed an overall improvement in the quality and quantity of sources with each successive draft of the research paper. Initially, many students gravitated toward web site sources, especially Wikipedia articles and national park web sites. In discussions following the initial draft, it became clear that there was confusion as to whether or not the National Park web sites were considered scholarly or not and some students struggled to understand that scholarly sources were available and preferable.

When invited to come speak to the class after the submission of the topic paper, the STEM librarian observed a small but quick learning curve between the first item in the "Scholarly or Not" activity and the last discussion item. Students began the discussion with limited confidence in knowing what a scholarly source was, how to identify one, and how these sources are accessed through the library. Through classroom discussion, the overall attitude changed from one of accepting any source with the word "geo" in the title as appropriate for the assignment to critically analyzing sources by talking through the evaluation of a source. Students became comfortable using the model scholarly journal article provided to compare to other sources and applying critical thinking skills as a group.

Following the STEM librarian's classroom visit, the majority of students expanded their resources to include more peer-reviewed journal articles in their drafts. It appeared the discussion of how to identify a scholarly source as well as instruction on how to access journal articles was contributory in the transition from web sites to journal articles. This assignment shows student growth from Wikipedia articles in preliminary bibliographies to meeting the ACRL Information Literacy Standards through the proper use of scholarly sources in the final paper. Some students continued to include web site sources in addition to their scholarly sources in subsequent drafts. While the majority of students referenced only scholarly sources by the end of the assignment, a few students struggled to make use of all of their references in the paper and therefore included extra sources in the references section that were not actually referenced in the paper. For the overall paper grades, students were assessed on both scholarly source citations in the references section and in the text (Appendix 2). Although some students achieved an expert level with respect to finding scholarly sources and reference citations, not all students completed in-text citations, demonstrating an additional knowledge gap in how to use scholarly sources in the text to support claims. Student follow-up questions centered on how to cite sources, such as government reports, and how to use the library's resources. Despite the instructor's urging, students did not make use of weekly office hours held by the STEM librarian in a nearby classroom to help improve their sources and citations.

Limitations

Although the data show an overall increase in the use of scholarly sources following the intervention, several other factors could contribute to the observed results. First, students may have spent insufficient time investigating sources in the early assignments and this resulted in the low number of scholarly sources. The assignment expectations may not have been clear, students may have lacked a clear focus for their papers, or students did not perceive the importance of spending time searching for scholarly sources as part of an outline. Second, the act of building on their subsequent drafts may have served as a catalyst for students to seek out additional scholarly sources. For example, the National Park web sites they initially relied on heavily were likely useful for describing the features of their selected sites but contained insufficient information to describe the geomorphic processes. Third, as students received feedback on drafts and delved more deeply into their topic, they may have been intrinsically motivated to find scholarly sources that would help them develop their understanding of their chosen site based on a growing interest in the topic. In fact, several students self-reported that once they started finding relevant scholarly sources, their interest in the topic increased and sources were easier to locate. Indeed, Shenton and Fitzgibbons (2009) highlighted several studies that demonstrated enhanced learning and motivation in students who selected their own topics. Thus, part of the struggle some students experienced both finding and using scholarly sources may have stemmed from the lack of topic focus or interest in the project itself.

Critically evaluating students' use of scholarly sources highlighted the student discomfort or lack of confidence in identifying, obtaining, and using scholarly sources. This was surprising given that most students had completed the majority of their science courses and were within one year of graduating. The library intervention initiated in this study, although successful for this particular writing assignment, was implemented too late in the curriculum to achieve both institutional and national scientific literacy goals. Earlier library intervention, perhaps in the second year of study, or repeated library intervention in multiple geosciences courses would likely be of even greater benefit (Waller & Knight 2012).

This study also reveals the importance of building focused, rather than generic, scholarly literacy instruction into writing assignments, especially in geoscience classes (Yocum & Almy 1999; Ochola & Peterson-Lugo 2003; Manuel 2004). Many students are not required to take a technical writing course as part of their curriculum and learn basic writing and citation through introductory English composition classes. While such courses provide a foundation for basic writing skills, the STEM disciplines differ quite substantially in writing styles, especially in the types of scholarly sources typically used. Students are missing an integral part of the scientific processes if they do not learn how to access, assess, and use scientific literature. For example, although in-text citations were not evaluated explicitly as part of this study, it became apparent to the instructor in reviewing the assignments for the overall paper grade that students were not actually using all of their scholarly sources to support statements in their paper. This indicated a lack of understanding that cited references should only include those sources used in the paper rather than a complete list of sources reviewed in the process of completing the paper. Students would greatly benefit from explicit instruction as to why references are important in scientific writing in addition to how to find and cite such sources.

Recommendations and Conclusions

The STEM librarian's classroom instruction was helpful in improving the students' abilities to identify and locate scholarly sources for their research papers. The authors have three recommendations for improving the assignment and library component in the course. First, clear communication of the instructor's expectations for appropriate sources in both verbal and print instructions is necessary throughout the review of the assignment guidelines. Looking at the improvements between the topic paper and the first draft, the instructor's expectation students include a variety of scholarly sources was not clear in the original assignment guidelines and the assumption of solid information literacy skills at the junior/senior student level was invalid. Although the STEM librarian held drop-in office hours weekly in a nearby classroom, students did not take advantage of this resource despite instructor feedback on drafts that suggested further research help and improvement was necessary. Clearly communicating, or perhaps requiring, that poorly performing students seek out additional librarian help may also help students take action toward improving their sources.

Second, students would benefit from library instruction earlier in the semester. The instructor and STEM librarian must assume students need instruction on differentiating between scholarly and popular sources, including web sites, books, government reports, and peer-reviewed journals, regardless of the student level (Davis et al. 1994). A study by McGuinness (2006) investigating faculty perceptions of information literacy reported that faculty perceive students develop information literacy intuitively and gradually and thus neglect the need for guidance and structured intervention in the classroom. The STEM librarian could visit the class before the topic paper is due to share this lesson with students and review appropriate databases for the assignment. This will remedy the various definitions of what constitutes "scholarly" and "popular" in the profession or for a certain geoscience sub-discipline such as geomorphology. Emphasizing the time and effort students will save using library resources instead of search engines should also remedy the over-reliance on popular sources, blogs, and Wikipedia.

Third, additional interaction with the STEM librarian over the course of the assignment would likely improve information literacy skills (Schloman 1993; Larsen 2005; McGuinness 2006). Repeated classroom visits would allow students to ask questions and focus on issues beyond identifying and discovering scholarly sources, such as the importance of correctly citing articles in the text and using all of the cited sources to support paper content. The outside view and expertise of the STEM librarian may be more effective at improving information literacy than the instructor (Shenton & Fitzgibbons 2009). Providing each student multiple opportunities to become comfortable with the process of finding and obtaining scholarly sources through the library web site would also likely improve student performance.

This work highlights the benefits of collaborative efforts between STEM librarians and faculty in specific disciplines. Although critical to good science, the importance of reviewing the literature is often not the focus of upper level writing assignments. The STEM librarian provided not only a wealth of knowledge surrounding resource availability and quality, but also provided an outside expertise that can augment the classroom lessons, especially concerning scientific literacy. In the future, the authors plan to continue implementing the "Scholarly or Not" activity in science classrooms at UNO and work toward clearer expectations for students evaluating and obtaining scholarly sources. An increasing awareness of the importance of STEM learning should lead to a more direct focus on information literacy, especially as the retrieval of information becomes easier and discerning its quality and appropriateness becomes more complex.

Tables

Table 1. Rubric for Student Performance Levels with Respect to Using Scholarly Sources for Each Assignment.

Performance Level Criteria	**Expert** Student achieves more than 80% of expected outcomes	**Advanced** Student achieves more than 50% of expected outcomes	**Novice** Student achieves less than 50% of expected outcomes
Topic paper: Uses 5 sources appropriate for topic	4-5 appropriate sources	3-4 appropriate sources	Fewer than 3 appropriate sources
Total students:			
Draft 1: Correctly cites 10 sources appropriate for the topic in References	Correctly cites 9 or more sources appropriate for the topic in References	Correctly cites 5-8 sources appropriate for the topic in References	Correctly cites 0-4 sources appropriate for the topic in References
Total students:			
Draft 2: Correctly	Correctly cites 9 or	Correctly cites 5-8	Correctly cites 0-4

cites 15 sources appropriate for the topic in References	more sources appropriate for the topic in References	sources appropriate for the topic in References	sources appropriate for the topic in References
Total students:			
Final Paper: Correctly cites 15 sources appropriate for the topic in References	Correctly cites 9 or more sources appropriate for the topic in References	Correctly cites 5-8 sources appropriate for the topic in References	Correctly cites 0-4 sources appropriate for the topic in References
Total students:			

Table 2. Student Performance Levels Each Assignment.

Rubric Data	**Student Skill Level**			
*Averaged scores	Expert	Advanced	Novice	Total
Topic Paper	8	2.5	5.5	16
Goal: 80%	65.6%			
Librarian Intervention				
Draft One	6.5	5.5	3	15
Goal: 80%	80.0%			
Draft Two	7.5	3	4.5	15
Goal: 80%	70.0%			
Final Draft	8	4	2	14
Goal: 80%	85.7%			

Table 3. Total Number of Sources Used by Students by Source Type.

Source Type		**Topic paper**	**Draft One**	**Draft Two**	**Final Draft**
Scholarly Journals		32	96	150	137
General Web Sites		15	18	10	11
Books		10	15	19	20
Government Web Sites		14	21	29	27
Thesis/Dissertation		0	1	3	4
Unknown Source		6	5	6	8

Appendix 1: Geomorphology Assignment and Timeline Provided to the Students

geol 4260 / GEOG 4260 / GEOG 8266 – Process Geomorphology
Term paper - Fall 2014

Term paper: You will compose a 6-8 page paper focused on the geomorphic history of a location of your choice. I can provide several possibilities, but you are free to choose any geographic location. Your task will be to research the site in detail, aiming to answer the question, "What are the processes that shaped this landscape over time to produce the features we observe today?" We will discuss topics, the paper timeline as well as how to find relevant information in class. The outline below describes the tentative paper deadlines. The final draft is due at the end of October so it will not conflict with other papers you may have due in other classes. You will get feedback after each draft to help guide you and the expectation is that you will incorporate any feedback in future drafts of the paper. I am happy to help direct the research and writing effort but all work must be your own. Please do not hesitate to ask questions – this is a challenging but useful exercise to practice using scholarly sources and communicate scientific ideas effectively.
Grading: The paper constitutes the final 40% of your grade. The paper will be broken down into several components, each worth a fraction of the 40%. You will have the opportunity to edit the paper and improve your grade, as this will be an iterative process.

Topic - Due Wednesday, September 3 (10 pts)
A roughly 1-page document including the following:

1. Location of choice (1)
2. At least three of the main landscape features observed at this location (1.5)
3. Detailed information you've learned so far (at least 10 items, can be bullet point) (5)
4. At least five resources you have found (maximum three books) (2.5)

First draft - Due Wednesday, September 17 (50 pts)
At least two pages of text in sentence/paragraph format including:

1. A description of the geographic location (5)
2. One paragraph each explaining the key components of the geosphere/hydrosphere/biosphere (15)
3. The question you are addressing (Why does this place look the way it does?) (5)
4. At least one paragraph describing the geologic history of your site (5)
5. At least one paragraph each describing the main landscape features observed at your location and the processes that produced those landforms (15)
6. At least 10 references cited within the text and in the references section (5)

Second draft - Due Wednesday, October 1 (75 pts)
At least four pages of text in sentence/paragraph format including:

1. A description of the geographic location (5)
2. One paragraph each explaining the key components of the geosphere/hydrosphere/biosphere (10)
3. The question you are addressing (Why does this place look the way it does?) (2.5)
4. At least one paragraph describing the geologic history of your site (10)
5. At least two paragraphs each describing the main landscape features observed at your location and the processes that produced those landforms (35)

6. At least 15 references cited within the text and in a references section (7.5)

Final paper - Due Wednesday, October 29 (100 pts)
Six-eight pages of text including:

1. A description of the geographic location and a regional scale and detailed map (2.5)
2. One paragraph each explaining the key components of the geosphere/hydrosphere/biosphere and a figure illustrating each of these components (5)
3. The question you are addressing (Why does this place look the way it does?), with specific reference to your site (2.5)
4. At least one paragraph describing the geologic history of your site and a figure that helps explain the geologic context (5)
5. At least three paragraphs each describing the main landscape features observed at your location and the processes that produced those landforms with figures that help describe each of these processes (20)
6. A clear evaluation of the relationship between the landforms and the processes (30)
7. One paragraph describing the tools you would use to study one of the processes at your site (10)
8. At least 15 references cited within the text and in a references section (5)

Appendix 2: Rubric Used for Assessment of Geomorphology Term Paper Assignments

Students were provided the rubric along with the instructions and timeline in Appendix 1 at the beginning of the semester.

Performance Level	**Expert** Student achieves more than 80% of expected outcomes	**Advanced** Student achieves more than 50% of expected outcomes	**Novice** Student achieves less than 50% of expected outcomes
Content			
Topic paper	-Location of choice -List at least three landscape features -8-10 bullet points/sentences of information	Some content is missing; 5-8 pieces of information	Content missing; < 5 pieces of information
Draft One	-Description of location -Question or theme that frames paper topic -Description of geosphere, biosphere and hydrosphere -Description of the	Some content is missing	Content missing, especially descriptions of geomorphic features

	geologic history of site -Description of main geomorphic features		
Draft Two	Introduction/Description of geographic location with interesting question, hypothesis or theme; succinct description of the geologic history of the site; relevant descriptions of the geosphere, biosphere, and/or hydrosphere; detailed descriptions of at least two geomorphic features and processes that created them; solid supporting information	Some content is missing or incomplete; question or theme is present but weak; some supporting information is poor	Content is incomplete and poorly developed; supporting information is poor
Final paper	Outstanding explanation of site and features with superior supporting information; insight and clear explanation of processes at work; creative and original analyses and thoughts; additional supporting evidence from figures or photographs	Good explanation of site and features with supporting information; some original analyses and insight into process but explanations under-developed or poorly supported	Decent explanation of site and features but too general/cursory or inaccuracies/flaws in reasoning; incomplete analysis of processes and/or poor supporting information

Rubric Used for Assessment of Geomorphology Term Paper Assignments.

Performance Level	**Expert** Student achieves more than 80% of expected outcomes	**Advanced** Student achieves more than 50% of expected outcomes	**Novice** Student achieves less than 50% of expected outcomes
Writing			
Topic paper: 1 page, bulleted or sentences *Start gathering ideas*	Bulleted information acceptable	---	---
Draft 1: 2 – 4	Information is largely presented in coherent sentences;		

pages, double-spaced *Get words and ideas onto paper*	paragraphs are starting to form around main ideas, but information may be repeated or unclearly stated	Over half of paper is not in sentence/paragraph format	No sentences or paragraphs.
Draft 2: 4 – 6 pages, double-spaced; complete sent./parag. *Craft a story with good supporting information*	Paragraphs are organized appropriately in the paper to address the question/theme; sentences are clear and succinct; ideas or information are not repeated	Some disorganized paragraphs and unclear sentences; some repeat of information or ideas	Paragraphs are disorganized; sentences are unclear/incorrect; information is repeated unnecessarily
Final paper: 6 – 8 pages, double-spaced; regional scale and detailed map *Eloquently communicate an interesting story focused on processes that shaped a landscape*	Excellent story and organization; interesting sentences; good grammar; very few spelling errors; polished	Decent story and organization; informal style and/or some awkward sentence structure; some spelling or grammar errors; reads more like a first draft	Disorganized and weak story, awkward sentence structure and/or inappropriate science style; poor spelling and grammar

Rubric Used for Assessment of Geomorphology Term Paper Assignments.

Performance Level	**Expert** Student achieves more than 80% of expected outcomes	**Advanced** Student achieves more than 50% of expected outcomes	**Novice** Student achieves less than 50% of expected outcomes
References			
Topic paper: Include 5 sources, maximum 3 books	4-5 sources	3-4 sources	< 3 sources
Draft 1: Include 10 scholarly sources	9 or more scholarly sources	5-8 scholarly sources	< 5 scholarly sources
Draft 2: Cite 15 sources correctly in references	Appropriate citations for 9 or more scholarly sources in references section	Appropriate citations for 5-8 scholarly sources in references section	Appropriate citations for < 5 scholarly sources in references section
Final paper: Cite	Appropriate	Appropriate	Appropriate

Final paper: Cite 15 sources in references list and in text correctly	citations for 9 or more scholarly sources in references and text correctly	citations for 5-8 scholarly sources in references and text correctly	citations for 5-8 scholarly sources in refs and text correctly

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