

Promoting Environmental Writing in Undergraduate Soil Science Programs

P. P. Motavalli,* M. D. Patton, R. A. Logan, and C. J. Frey

ABSTRACT

Revision of soil science curricula to include opportunities for student environmental writing may help to overcome declining enrollments in soil science by attracting undergraduate students interested in environmental issues to learn about soil science. Experience in environmental writing also may help prepare future soil science and natural resource professionals to communicate with diverse audiences in a variety of formats and media. Starting in 2000, the University of Missouri (MU) Soil Science Program and the MU Campus Writing Program initiated a research and teaching effort to: (i) assess the need for science and non-science majors to improve their writing skills; (ii) develop a writing-intensive soil science course as part of the writing across the curriculum (WAC) program that would improve writing skills and encourage students to learn more about soil science and its role in addressing environmental issues; and (iii) evaluate the success of this approach. A survey of former MU science and non-science majors indicated that both groups ranked writing skills as important in their current jobs. Most undergraduate students currently enrolled in soil science courses experienced limited opportunities to write in both their secondary and undergraduate science classes. An undergraduate writing-intensive soil science course entitled *Soils and the Environment* was initiated to emphasize the role of soil science in environmental issues and provide writing exercises for realistic target audiences. Student writing from the course was published with the assistance of MU journalism and graphic design students. Student evaluations indicated that the course improved their writing skills and stimulated their enthusiasm for the subjects discussed in the course. The results of this experiment to include environmental writing opportunities in a soil science curriculum suggest that writing may be an important active-learning tool to promote undergraduate student interest and motivation to study soil science.

EFFECTIVE WRITING SKILLS are an important outcome of an undergraduate education. Among the many benefits of effective writing skills in science-based professions are improved communication and enhanced reasoning and organizational capabilities (Ryan and Campa, 2000). Writing can advance learning for several reasons, including promoting the synthesis and integration of complex concepts and situations (Emig, 1977). Research in linguistics, cognitive psychology, composition, and learning theory suggests that writing enhances critical understanding of a subject (Britton et al., 1975; Applebee, 1984; Durst, 1987; Langer and Applebee, 1987; Bean, 1996). For example, engineering faculty who integrated writing into their engineering design course note that “writing

is an excellent process for developing engineering judgment” (Woerner et al., 1996). Scientific reports require critical thinking, for example, when scientists justify their use of a particular methodology (Woerner et al., 1996). As Bean (1996) says about writing in any discipline, “Quite simply, writing is both a process of doing critical thinking and a product communicating the results of critical thinking.”

Increasingly science-based professionals are being challenged to communicate with a variety of audiences, including both urban and rural communities, who possess a wide range of technical knowledge (Smiles et al., 2000). For professionals working in soil science, improvements in communication skills are urgently required to promote public awareness of their discipline and to demonstrate the relevance of science to solving important environmental problems (Franklin and Boersma, 1990). Science-based professionals may write for different audiences in a variety of formats, including technical reports and memorandums, fact sheets, scientific and non-scientific journal articles, project proposals, posters and, increasingly more important, text for the World Wide Web and other media (Day, 1995; Davis, 1997; Gross et al., 2002).

Approximately one-half of U.S. colleges have now developed writing across the curriculum (WAC) programs, which are based on the premise that “writing should be an integral part of the learning process throughout a student’s education, not merely in English courses but across the entire curriculum” (Townsend, 2002). In 1985, the University of Missouri (MU) in Columbia, MO, initiated a WAC program with a three-part requirement for all undergraduate students with the objective of promoting writing competency (Townsend, 1997; Patton et al., 1998). This requirement includes a freshman writing course followed by two “writing-intensive” (WI) courses, one of which must be in the student’s major. The MU writing-intensive courses develop student writing skills within their own major and also provide opportunities to improve writing via supervised editing and revision. The MU Campus Writing Program oversees more than 100 writing-intensive courses each semester, of which approximately 40 are in science-based subjects.

Traditionally, soil science curricula have emphasized proficiency in technical subjects, including chemistry, physics, mathematics, and biology. The primary subdisciplines of soil science include soil physics, soil chemistry, soil microbiology, soil genesis and classification, soil conservation, and soil fertility and plant nutrition. These subdisciplines have been both the basis by which soil scientists identify themselves professionally as well as the guide for the organization of most soil science undergraduate and graduate curricula. However, a decline in the number of undergraduate students majoring in soil science during the last 20 yr has stimulated interest in revising soil science curricula to make them more relevant to stu-

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Abbreviations: MU, University of Missouri-Columbia; MDNR, Missouri Department of Natural Resources; WAC, writing across the curriculum; WI, writing intensive.

dent interests and career opportunities (Groffman et al., 1991). One major trend in this revision has been to emphasize the role of soil science in understanding and managing major environmental issues, including water and atmospheric pollution, waste management, and soil erosion and runoff (Letey, 1994; Weil, 2002).

Among the student-perceived weaknesses of the MU soil science curriculum have been a lack of a sufficient environmental identity to interest students, a dearth of opportunities for writing experiences, and the absence of bridging courses between the introductory soil science course and the upper-level courses that emphasize soil science's subdisciplines. An overall problem for MU, as well as other university soil science programs, was that for many potential undergraduate students, the relevance of soil science to major environmental issues was not self-evident (Franklin and Boersma, 1990).

The objectives of our research and teaching efforts starting in 2000 were to: (i) assess the need for science and nonscience majors to improve their writing skills; (ii) develop a WI soil science course as part of the WAC program that would improve writing skills and encourage students to learn more about soil science and its role in addressing environmental issues; and (iii) evaluate the success of this approach. In the process of achieving these goals, we also hoped to draw upon the expertise of several academic programs that worked with student writing assessments and environmental writing. An additional benefit of this interaction would be the promotion of collaboration among undergraduate students interested in environmental issues in different disciplines, including soil science, fisheries and wildlife, forestry, biological engineering, environmental journalism, and fine arts.

METHODS

Survey of Former Science and Nonscience Students

A computer-assisted telephone survey was sponsored by the MU Campus Writing Program and conducted by the MU Center for Advanced Social Research during the summer of 2000. A random sample of former MU students who had graduated with an undergraduate degree from MU between 1995 and 2000 and who had taken a minimum of one WI course was surveyed. At least eight attempts were made to complete an interview at every sampled telephone number. The calls were scheduled during days and evenings of the week to maximize the chances of making contact with a potential respondent. All refusals were recontacted at least once. The response rate of the survey was 75%. The survey included questions related to former MU students' attitudes about writing and the relevance of writing to the former MU students' current jobs.

Survey responses were separated based on whether the former student's major was science or nonscience based. Ninety-four respondents identified themselves as science majors in fields, such as agricultural economics, biology, engineering, computer science, and fisheries and wildlife. Two hundred thirty-eight respondents identified themselves in nonscience majors such as English, journalism, and education.

Survey of Undergraduate Students in Soil Science at University of Missouri-Columbia

Forty-two undergraduate students enrolled in the introductory soil science laboratory and other MU undergraduate

soil science courses were surveyed by the MU Campus Writing Program during the 2001 fall semester. A short written questionnaire was used to assess their perceptions and experience with science writing. Student backgrounds ranged from sophomores to seniors majoring in primarily technical disciplines, including plant science, forestry, geology, fisheries and wildlife, soil science, and biological engineering. The respondents were asked to indicate their level of agreement with statements on a scale of 1 to 7 with one being *strongly disagree* and seven being *strongly agree*.

Course Evaluation

Two methods were used to evaluate the WI soil science course. Formal print student course evaluations with a 1 to 5 scale with 1 being *unacceptable* and 5 being *excellent* were administered to students taking the course at the end of the semester during 2000 and 2001. Additional space for written comments was included on the evaluation questionnaire.

Another method used for course evaluation was oral exit interviews of students in the WI Soils and the Environment course conducted by the MU Campus Writing Program at the end of the fall semester in 2001. These interviews also included undergraduate and graduate students from the MU School of Journalism and the MU Fine Arts Department who had participated in developing the student publication from the course.

SURVEY RESULTS

Evidence of Need for Writing Skills and Experience

Ninety-five percent of former nonscience majors and 89% of former science majors strongly agreed or somewhat agreed with the statement that writing helped them to learn (Fig. 1A). Similarly, 95% of the former nonscience majors and 88% of former science majors strongly agreed or somewhat agreed with the statement that writing was an important part of their college education (Fig. 1B). The respondents also assessed the importance of a variety of work-related skills on a scale of 1 to 7 with 1 being *not very important* and 7 being *very important*. Eighty-two percent of nonscience majors and 79% of science majors rated writing skills from 5 to 7 as important in their current jobs (Fig. 1C). Approximately 65% of the both nonscience and science majors agreed (represented by a 6 or 7 on a 7-point scale) that the following skills also were important in their current jobs: analyzing people, events, or texts; being able to adapt a message to a particular audience; reporting or summarizing events accurately; and knowing the particular writing or communication conventions or formats used in their profession (data not shown).

Writing Skills and Experience among Undergraduates Taking Soil Science Courses

The students polled in the survey of soil science courses reported mixed experiences in previous courses that incorporated science writing (Fig. 2 A–C). More than 50% of the respondents strongly agreed (rating 5–7) with the statement that their secondary school science teachers seldom asked them to write (Fig. 2A). About 50% also agreed that their science writing experience was limited to writing up laboratory reports and short answers on tests (Fig. 2B). Approximately 46% of the

students reported no prior experience writing for a publication, but the wide range in response to this statement may have been caused by student confusion over what constitutes a publication (Fig. 2C).

Despite the lack of apparent student writing experience, most students (79%) considered themselves strong writers

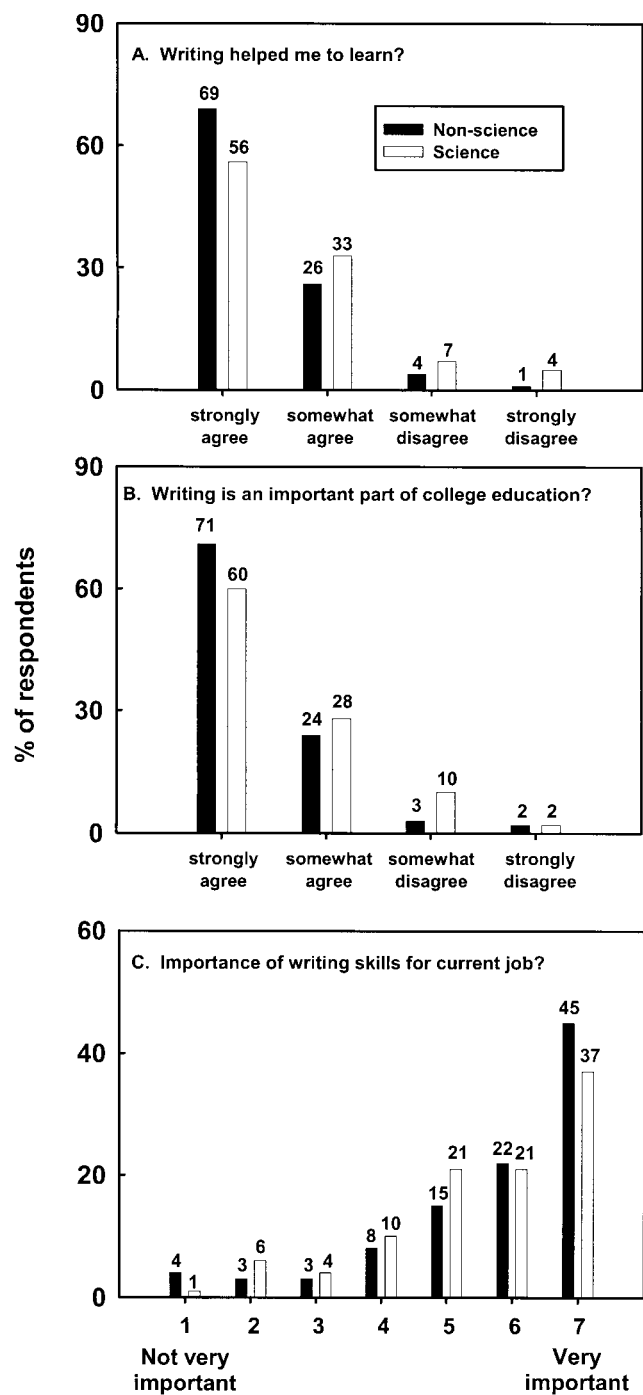


Fig. 1. Results of a survey conducted in 2000 by the University of Missouri-Columbia (MU) Campus Writing Program of former science and nonscience majors who had graduated from MU between 1995 and 2000. Figure heading indicates statement that respondent rated for (A) and (B) on the basis of agreement with the statement and for (C) on a scale of 1 to 7 with 1 being *not very important* and 7 being *very important*. Numbers above bars are proportions of each response in percent.

compared with their peers (Fig. 3A). Many of the students surveyed (57%) also perceived that writing helped them to learn (Fig. 3B), and 53% agreed they would prefer expository writing to quiz/examination forms of testing about science content (Fig. 3C). Similarly, WI course evaluations collected by the Campus Writing Program during the last 15 yr (data not shown) suggest that, after experiencing both writing and quiz/examination forms of assessment, most students prefer writing to true/false, multiple choice, and similar test instru-

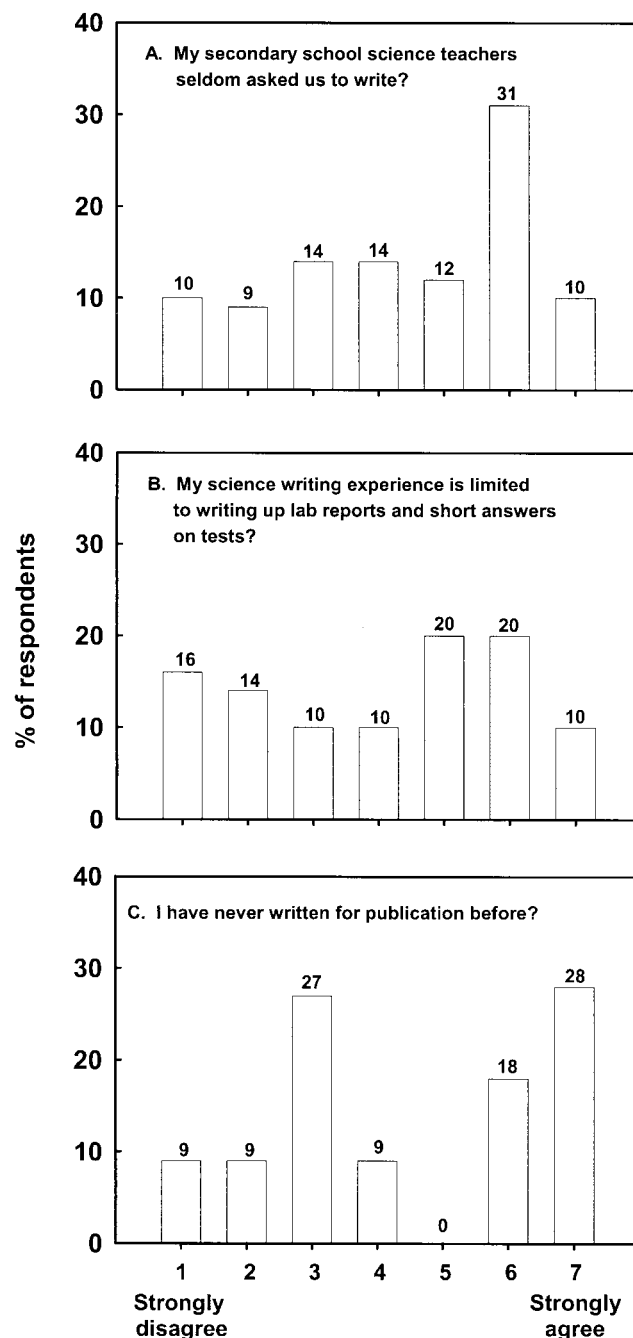


Fig. 2. Results of a survey conducted in 2001 of University of Missouri-Columbia (MU) undergraduate students enrolled in introductory soil science courses indicating their writing experience. Figure heading indicates statement that respondent rated for (A), (B), and (C) on a scale of 1 to 7 with 1 being *strongly disagree* and 7 being *strongly agree*. Numbers above bars are proportions of each response in percent.

ments. Thus, when students had an opportunity to write within their major, they often become advocates for the experience.

ENVIRONMENTAL WRITING

Course Design

An undergraduate WI course in the soil science program entitled *Soils and the Environment* was initiated in the fall semester of 2000. The objectives of the course were (i) to de-

velop an understanding of the role of soil properties in biogeochemical processes and environmental pollution; (ii) to discuss and illustrate the impact of human activities on soil and environmental pollution; (iii) to examine methods to manage soils to prevent and remediate environmental pollution; and (iv) to develop skills in the analysis of environmental problems and in communicating with different audiences. Based on course design criteria suggested by Fink (2003), the primary types of learning emphasized in the course were foundational knowledge and application and integration, with less emphasis on the human dimensions, caring/valuing, and learning how to learn.

The course catalog description of the *Soils and the Environment* course is the following:

Addresses the role of soils and soil properties in environmental pollution and management. Emphasis will be placed on carbon, nitrogen, phosphorus, and sulfur transformations and transport in natural and disturbed ecosystems and on soil management practices and technology to prevent or remediate environmental pollution.

The prerequisites for the course are an introductory soil science course, 3 h of introductory inorganic chemistry, and an introductory writing course.

To reinforce the relevance of the course to environmental issues, an effort was made to supplement the course's textbook (cf. Pierzynski et al., 2000) with appropriate readings from current newspaper, magazine, and web-based articles addressing ongoing environmental problems (e.g., hypoxia in the Gulf of Mexico) and events (e.g., global environmental conferences), especially those occurring locally (e.g., city-wide debates over implementation of storm-water regulations). Among the soils-related environmental issues discussed in the course were global-warming, erosion, water pollution, acid precipitation, waste disposal, and the environmental impact of land-use practices (Table 1). Students who took a course entitled *Soils and Environmental Quality* at the University of Maryland were surveyed on the first day of classes (Weil, 2002); the survey results showed that topics such as water pollution and soil erosion and conservation have also been of interest to undergraduate students.

Writing Assignment Principles

Fulwiler (1986) and Ryan and Campa (2000) note writing assignments are more effective when placed in a meaningful disciplinary and job-related context. For the course, the instructor carefully considered the type of writing that might be requested of students during their professional careers, including proposal writing, issue position papers, technical reports, web-based text introducing an issue for discussion, popular articles for the general public, and an oral presentation with presentation software (Table 1). Each of the writing assignments was placed in the context of a specific situation. For example, for a position paper, each student acted as an advisor to the Director of the Missouri Department of Natural Resources (MDNR) and argued the merits of the agency taking a particular position on an environmental issue and possible new regulations or programs. The positions were then presented to the class, which role-played how different interest groups and other MDNR staff might react to the new policy.

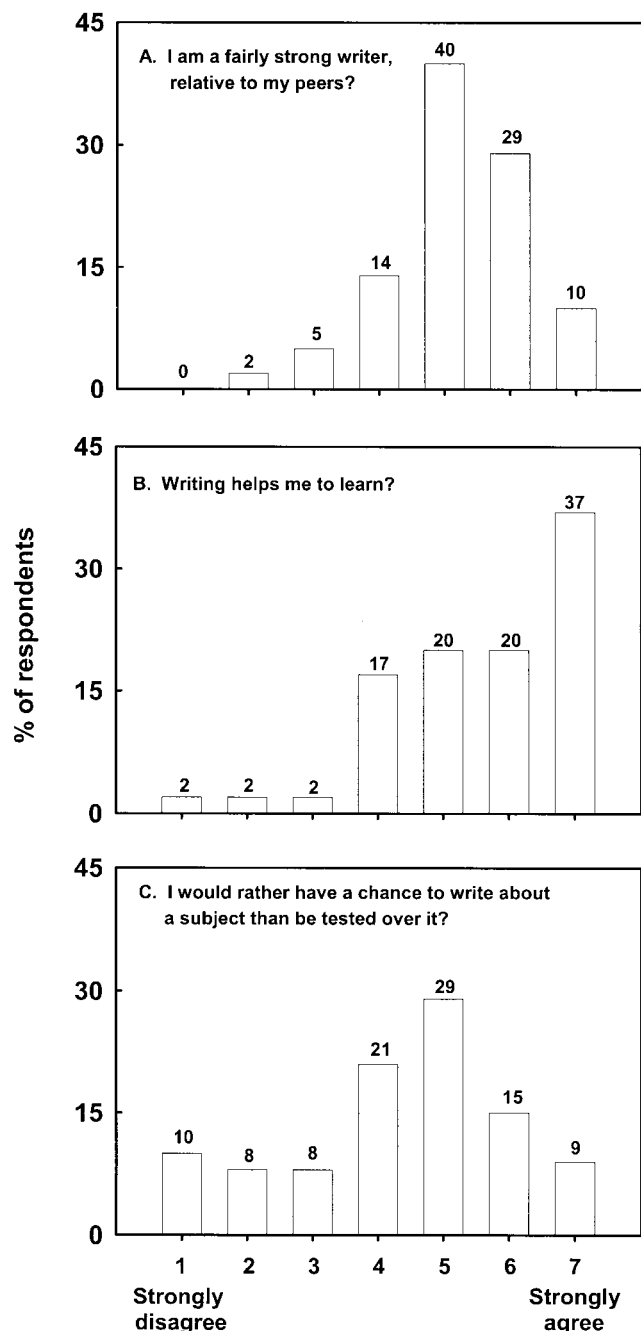


Fig. 3. Results of a survey conducted in 2001 of University of Missouri-Columbia (MU) undergraduate students enrolled in introductory soil science courses indicating their perceptions on writing and their writing ability. Figure heading indicates statement that respondent rated for (A), (B), and (C) on a scale of 1 to 7 with 1 being *strongly disagree* and 7 being *strongly agree*. Numbers above bars are proportions of each response in percent.

Fulwiler (1986) and Ryan and Campa (2000) also recommend that writing assignments should identify a target audience for whom a student paper should be written. This learning strategy requires that students tailor their writing styles to an audience. Since an instructor remains the arbiter of the assessment of the writing assignment, students may still write what they perceive an instructor wants. However, students may have additional motivation for writing when they are thinking of a realistic audience.

In addition to writing situationally for target audiences, instructors added two features to writing assignments to enhance student interest in both writing and soil science. First, for several writing assignments, students were asked to include quotations from technical experts or individuals affected by an issue and for other assignments; instructors, therefore, required students to use books and journal articles. These requirements were intended to stimulate the “learning how to learn” type of learning that Fink (2003) advocates, which fosters self-directed learning among students. To fulfill this requirement, some students consulted for the first time with other faculty and staff in the soil science program, other departments, and community groups and became aware of their environmental expertise and activities. The use of book and article references were intended to force students to use materials other than from the Internet and to promote discovery of resources in the library or bookstore. A positive by-product of quotation seeking was to foster student confidence in interacting with experts and peers, who are and can be future technical and nontechnical sources of information. Interaction promotes networking, which is critical for most professions. Conversely, the instructors were sensitive about the needs of students who might be intimidated by the quotation requirement because they lacked confidence in their interpersonal communication skills.

Second, instructors recognized that publishing motivates student interest. For decades, student publication has been recognized as a strategy to make class-based writing meaningful and to motivate students to revise their prose (Stanton, 1950; Wilson, 1955; Marland, 1970; Andrews and Creed, 1996). Since writing for publication implies an audience, it also inculcates a sense of responsibility and legacy that cannot be duplicated by in-class experiences. Gopen and Swan (1989) note that undergraduates are more likely to be effective communicators when they are conscious of a reader interpreting their writing.

For students in journalism and other fields, in which writing is a primary activity, the development of a portfolio documenting writing experience is critical for career success. However, in soil science, opportunities for publication are often more available for graduate students, and these writing opportunities are mostly targeted for scholarly publications. To provide an opportunity for an undergraduate publication focusing on environmental issues, in the first year of the course, we took student writings from the popular article assignment, which the students had revised, and compiled them in a student magazine for publication. In the second year, we approached graduate students interested in environmental journalism within the MU School of Journalism and graphic design students in the Fine Arts program to supervise the editing and publication of the student magazine. The resulting publication is available at <http://web.missouri.edu/~soil->

Table 1. Soils and the environment course outline with topics and writing assignments.

Lecture and discussion topics	Writing assignment†
Introduction and overview	
Scientific writing	
Definitions and environmental legislation	
Atmosphere	
Hydrologic cycle	Web-based issue discussion text
Soil resources: Genesis and classification	
Soils: Physical properties	
Soils: Chemical properties	
Soils: Biological properties	
Carbon cycle	
Carbon in soil	Environmental article
Global climate change	
Nitrogen cycle	
Nitrogen in soil	
Nitrogen management	
Phosphorus cycle	Research proposal
Phosphorus and the environment	
Sulfur and the environment	
Trace elements	
Environmental monitoring	
Soil and water quality	
Microbial pathogens	Technical position paper
Soil erosion	
Fate of pesticides	
Waste disposal	
Acid precipitation	Class oral presentations
Remediation	
Risk assessment	

† Writing assignments are shown in order and at the corresponding topic they are assigned.

www/290_2002/index.htm (verified 22 Aug. 2003) (see Table 2 for titles and topics addressed in the student magazine). An additional benefit of the publication has been its potential use

Table 2. Titles and topics of articles in the student environmental publication during 2000 and 2001.

Year	Title of article	Topic
2000	You Can Have Your Tomatoes and Eat Them Too...In the Sun!	Environmental effects of the fumigant methyl bromide
	Mother Nature Takes Over Wastewater Treatment Chores	Treatment of wastewater using constructed wetlands
	Futuristic Science: Controlling the Weather	Environmental effects of man-made weather modification
	Holding On to Your House... Soil Hydrology Gives New Meaning to the Term “Mobile Home”	Environmental impacts of soil hydrology
	Chlordane: A Glimpse of Things to Come	Ecological impact of pesticides in soil
2001	Health Hazards in Historical Homes: Problems with Lead Contamination	Health impacts of lead in paint
	Reclaiming Missouri’s Moonscapes with Microbes	Microbial methods to remediate soils contaminated with lead
	Illegal Dumping Near Our Caves!	Environmental effects of illegal dumping near caves in Missouri
	MBTE: A Concern with Your Drinking Water	Environmental effects of gasoline additives
	Phytoremediation: A Cost Effective and Environmentally Friendly Method for Soil Pollution Cleanup and Prevention	Benefits and costs of using phytoremediation
	Riparian Buffers: They’re Good for the Soil & Your Drinking Water, Too	Uses of riparian buffers to prevent water pollution
	Seeking Clarity in Murky Waters: Phosphorus Effects on Water Quality in Missouri	Sources and effects of phosphorus in water resources in Missouri
Would You Please Pass the Salt? The Problem of Soil Salinity	Effects of irrigation and management on soil salinity	

Table 3. Student evaluation comments for the University of Missouri-Columbia writing-intensive course, Soils and the Environment (fall semester, 2001).

Question	Student comments
The writing assignments in this class have been designed primarily as a way to help you think about the subject matter and/or this discipline. Which assignments have been most helpful in this regard, and why? Which have been least helpful? Why?	<ul style="list-style-type: none"> • The report—it was more in my style of writing. The article was least helpful because it was hard for me to know what was important to explain. • All were helpful—different assignments required different techniques—articles, sci. reports, presentations, etc. each was unique and made you develop different skills • I believe all of the assignments helped. I built off of each assignment in helping me write the next assignment. • The popular articles and the web assignments were best because they forced me to write in a different style. • Proposal to the state, helpful writing in the real world. • They all were very helpful because they worked different angles of writing, thinking, and the subject material. • The written papers were most effective because I was able to present information in a more personal way. The web assignment was least effective since I was more focused on finding websites to include rather than writing about the information.
What advice would you give your teacher as he or she reconsiders the role of writing in this course?	<ul style="list-style-type: none"> • Make us do different topics on each paper. That will help us learn more material. • Spread projects out more so they don't overlap with due dates. • I wouldn't change it. None of the assignments were too extreme. The scientific writings definitely increased my knowledge. • Move the popular article to earlier in the semester to give students more opportunity to be involved with the newsletter. • Nothing really, keep format the same. Maybe more points that are not paper related to help grades. • Keep the writing assignments the same, they worked out well.
How would you compare your learning experience in this course to your experiences in other non-writing-intensive courses?	<ul style="list-style-type: none"> • Better than average. • I think it was equally good. Not really as boring as some of my other classes due to my interest in the subject matter. • Above average. • It helped me know. • Learned much better here. I feel I will retain more. • I was able to learn better since I had to research and write about the environmental issues rather than just sit and listen to a lecture.

as part of recruiting literature for attracting students to soil science courses and the soil science major.

Evaluation of Experience

Student enrollment in the WI Soils and the Environment course was low during the first 2 yr it was taught (five in 2000 and eight in 2001). In contrast, Weil (2002) reports that the undergraduate Soil and Environmental Quality course at the University of Maryland, which is targeted for nonscience majors and with fewer science prerequisites compared with the course taught at MU, attracts about 125 to 150 students per year. The small number of students in the Soils and the Environment course at MU fostered class discussions and close teacher–student interaction, which may have helped to further improve student writing and oral communication skills.

Formal student course evaluations on a 1 to 5 scale with 1 being *unacceptable* and 5 being *excellent* indicated that 86% of the students believed the course was excellent in helping to improve their writing skills (overall ranking average of 4.86). One student commented that the learning experience in the WI course was better than experiences in non-WI courses “since I had to research and write about the environmental issues rather than just sit and listen to lectures” (see Table 3). All of the students evaluated the course as being either *good* (57%) or *excellent* (43%) in helping to stimulate their interest in and enthusiasm for the subjects discussed (overall average ranking of 4.43). However, students disagreed on which writing assignments were most beneficial (Table 3) and assigned an average ranking score of 4.14 on the question of whether the writing assignments were integrated with course content (data not shown). Additional concerns were expressed in student comments about the dependence of the grading of the course on writing assignments, the lack of required di-

versity of topics covered in the writing assignments, and the order and overlapping of the due dates of the assignments and required revisions (Table 3).

Even if some students may have been initially skeptical about the value of writing (for publication or not), oral exit interviews of students in the WI Soils and the Environment course suggest that students left the course with more positive attitudes about writing, increased confidence in their own ability to write, and increased ability to produce text for both technical and nontechnical audiences. The journalism graduate student who edited the student publication confirmed the undergraduate students' appreciation of the instructor's enthusiasm and knowledge about both soil science and scientific writing. Several students said they were more motivated to write well for someone they respected than they would if they did not hold the professor in high regard.

The journalism graduate student expressed her belief that a competitive journal in which some articles may be accepted or rejected on merit would stimulate even better writing skills. She also thought that students needed more experience reading the kinds of text they are producing. Given the difficulty of writing for both technical and lay audiences, some teaching exercises may need to be included in writing-intensive courses to demystify science writing. Both Koprowski (1997) and Moore (2000) report success critiquing scientific papers in the classroom and working with students to identify the rhetorical strategies used to appeal to particular target audiences.

CONCLUSIONS

The integration of a WI course into the soil science curriculum at the University of Missouri has helped to improve undergraduate student writing skills and has encouraged them

to learn more about soil science and its role in addressing environmental issues. Based on our survey data, students enrolled in soil science courses initially have some recognition of the importance of writing for learning but have limited interest in and opportunities for writing experience during their undergraduate education. However, once students experience writing opportunities and enter professional careers, their awareness of the importance of writing skills is enhanced. By providing writing experiences for natural resource undergraduate students with assignments that target different audiences and various writing styles on environmental issues, the soil science writing-intensive course serves an important role in the soil science curriculum and helps to increase student confidence in their own writing abilities. In addition, the approach of the course to emphasize the role of soil science in current environmental issues and promote active learning through writing stimulates student learning in soil science and other environmentally related natural resource disciplines.

Our experiment in promoting student environmental writing in the undergraduate soil science program has highlighted the importance of active learning methods as an effective tool for student learning. Among the many advantages that soil science has as a discipline over several other technical fields is the relevance of soil science principles to understanding and solving on-going environmental problems. Writing about relevant environmental issues and working with students in other disciplines to communicate effectively to different audiences is a motivating and enriching experience. For many undergraduate students, seeing their name in a publication for the first time is a proud moment that they can share with their relatives and include in their portfolio for future employers.

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