Assessment of an On-line Erosion Lesson as a Teaching Tool in Introductory Soil Science[1]

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Abstract

The objective of this study was to evaluate student learning and student satisfaction when computer technology is used as a tool to teach soil erosion concepts. The methods compared were; 1) traditional-interactive utilizing textbook, worksheets, and small group discussion, and 2) on-line lesson, utilizing photographs, illustrations, animations, and an interactive calculation model that allowed students to manipulate factors influencing erosion. All students took a ten-question objective pre-test prior to the lesson, followed by ten-question objective post-test upon lesson completion. Within one week of lesson completion, students completed a survey on Student Assessment of Learning Gains (SALG) to assess satisfaction with each teaching method. Neither pre- nor post-test scores differed between the two teaching methods. Student satisfaction, as measured by SALG ratings, was significantly higher overall for students completing the on-line lesson compared to students using the traditional-interactive method. Thirty-one out of the 43 SALG survey question scores, encompassing the area of lesson design, skills gains, learning gains, and understanding, were significantly higher for the student group taking the on-line lesson. With proper implementation of instructional design and technical support, incorporation of on-line lesson in soil science classes is an effective way to enhance student interest, motivation, and satisfaction in the learning process.

Introduction

The introductory soil science course at the University of Nebraska enrolls up to 240 students annually. The majors represented in the course are diverse, encompassing the agricultural, social, biological, and physical sciences. Since 1988 the course has been taught using an active, small-group learning style covering 25 modularized lessons on soil science topics (Sorensen et al., 1988). The majority of these lessons are worksheet activities completed in a small group setting (three to four students). The course also incorporates hands-on activities to demonstrate soil science concepts. While the current paper-based lessons have been reasonably effective in building the students' comprehension, additional tools such as on-line lessons offer opportunities to enhance the educational experience. These tools provide support for students of diverse majors, academic and ethnic backgrounds, and learning styles.

Current university data shows that students are increasingly becoming proficient in utilizing computers as educational tools (Donaldson, 1999). Through accumulated experience, teachers believe that students are more "on-task" and have more positive feelings when they use computers to accomplish tasks (Becker, 2000). Lepper (1985) suggested several ways by which computer-based learning activities might lead to increased student engagement on academic tasks. First, computer activities that are challenging motivate students to seek solutions to a problem; second, computer activities can stimulate student curiosity; and third, computer activities can give students a sense of independent control that encourages sustained and intense effort.

George (2000) concluded that these alternative approaches in instructional design and delivery assisted the university of meeting its mission in undergraduate education. While numerous studies have addressed the teaching and learning environment from multiple perspectives, a holistic approach related to on-line delivery has the potential to strengthen all facets of undergraduate education (Miller and Husmann, 1996). The most productive assessment of the teaching and learning environment can be provided by the students who actually enroll in these courses that are designed through an on-line delivery strategy (Miller and Husmann, 1995). The technology integration in the develop-

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ment of the on-line erosion modules within this study supports the findings that allows individual students to determine the direction and sequence of their own learning (Lu and Molstad, 1999). Individual learners have individual needs and the on-line learning modules need to have structure (George, 2000), but yet have the flexibility to allow individual learners to interact and determine their own sequence through the lesson (Lu and Molstad, 1999). This positive engagement on use of computer by students as an educational tool may be due to improved design of on-line lessons rather than the delivery method.

On the majority of college campuses, students complete course evaluations to meet the needs for institutional commitment for course improvement related to content and context, instructor evaluation and effectiveness, and for potential promotion and tenure considerations for faculty with teaching appointments. Numerous studies have found student evaluations to be excellent learning and assessment tools used to improve undergraduate education (Menges and Mathis, 1988; Perry and Smart, 1997; Tricker et al., 2001). There is considerable concern that student course evaluations should also be viewed with skepticism as the only means of determining course effectiveness and student learning (Wallace and Wallace, 1998; White, 2000). In a recent study by Husmann (2003), students who participated in an on-line delivered course provided substantial feedback on course development, design, and delivery. This contributed greatly to the professional practice within the framework of teaching developed by Danielson (1996) related to the classroom environment. The feedback provided to the instructor may provide valuable insight into the content of the course as well as the method of delivering the course.

As a supplemental teaching tool, we developed a web-based interactive soil erosion lesson, implemented it in the introductory soil science course, and assessed its usefulness. Our hypothesis was: the addition of this web-based interactive on-line lesson in soil erosion will stimulate student interest, effort, and engagement, and foster a deeper understanding of soil science. The objective of this project was to evaluate an on-line web-based soil erosion lesson as a supplemental resource for introductory undergraduate soil science.

Materials And Methods

The soil erosion topic was the 19th and 13th lesson in the sequence of lessons presented to students in the fall (2001) and spring (2002) semesters Soil Resources course, respectively. The overall objective of the lesson is to enhance student learning on the causes of soil erosion, the environmental degradation that results from erosion, and about the soil management practices that can be implemented to prevent and mitigate erosion's occurrence. There are 13 learning objectives in the soil erosion lesson. The student will:

1. Differentiate between geologic and human-accelerated erosion.
2. Describe the mechanisms of soil erosion (detachment, transport, and deposition).
3. Describe four types of water erosion.
4. Describe each of the six factors affecting the amount of soil lost by water erosion.
5. Locate values for each of the six factors affecting soil loss appropriate for a given situation.
6. Calculate soil loss from water erosion using the Universal Soil Loss Equation (Thien, 1999).
7. Determine suitable values for one or two of the six soil loss factors to meet the erosion tolerance level for a selected soil type.
8. Calculate the depth of soil lost from a field if given the soil loss in tons per acre.
9. Describe the five factors that affect the amount of soil lost by wind erosion.
10. Describe three forms of wind erosion.
11. Identify particle size ranges which are susceptible to each of the three forms of wind erosion.
12. Given a field situation, identify what kinds of erosion are possible.
13. Select erosion control measures for a given field situation.

The goal

In the traditional-interactive lesson format, control groups used an eight-page worksheet addressing the thirteen learning objectives. The worksheet was divided into eight sections addressing 1) Kinds of Erosion; 2) Determining Erosivity; 3) Types of Water Erosion; 4) The Universal Soil Loss Equation (USLE); 5) Calculation of Soil Loss; 6) Types of Wind Erosion; 7) Recommendation for Erosion Control; and 8) Listing Causes of Erosion in Nebraska. The worksheet is comprised of short-answer, fill-in-the-blank, matching, and computation questions. This format is basically self-instruction where a group of three to four students complete the worksheet together to facilitate exchange of ideas and enhance discussion. The worksheet had three formal instructor checkpoints, at the end of sections 3 and 5, and at the end of the lesson, although instructor-directed questions are encouraged at any time. These checkpoints allowed students the opportunity to discuss their answers with the instructor and ask questions.

The content of the soil erosion on-line lesson was created based on the learning objectives. The on-line lesson had 13 pages comprised of text, 17 photos, eight figures, one table, one animation, and one interactive USLE modeling program. The animation in the lesson shows the process of wind erosion, depicting the dynamics of small and large soil particle movement due to wind. A quantitative soil erosion program based on the USLE, adapted from Kansas State University (Thien, 1999), was used as an

interactive learning resource at the end of the lesson. The interactivity of the USLE model allowed students to change relevant variables and assess the effects of these changes on predicted soil erosion loss under Nebraska soil, climate, and cropping system conditions. Students worked on these lessons in a computer classroom. As students worked on the lesson, they completed a four-page paper worksheet consisting of 11 questions, addressing mechanisms of water and wind erosion, factors controlling erosion, and management measures for erosion. The last question in the worksheet provided a field scenario where the management practice was eroding soil above the tolerance (T) level of 5 T A-1. Using the Nebraska version of the USLE program, students first evaluated the amount of loss from the current field scenario. The next step was then for students to change relevant variables until they obtained a soil loss rate below the T level. The instructor was available to answer both lesson and computer related questions.

In the fall semester of 2001, 55 students out of the 90 students enrolled in Soil Resources at University of Nebraska-Lincoln completed an on-line learning lesson, created by the authors, on the topic of soil erosion and conservation during the allotted two-hr class period. Student participation would have been larger, except the lesson coincided with the Thanksgiving holiday season that resulted in almost half of the students being absent due to travel. As a control group, 77 students in the spring semester completed a non-computer based lesson using the traditional interactive format during the two-hour class period, addressing the same learning objectives. Each student in both the experimental and control groups completed a pre-test based on assigned readings and a supplementary study outline before beginning the lesson. A post-test was administered to students at the end of the two-hour session. Both the pre and post-tests consisted of 10 multiple choice questions created to address the learning objectives of the lesson. These pre- and post-test questions remained the same for both semesters. Both experimental and control groups were given the same advance reading assignments and a 45-minute introductory lecture, and were instructed by the same course instructor in the fall and spring semesters. Within one week after completing the lesson, students completed the Student Assessment of Learning Gains (SALG) adapted from Seymour, (1997).

The SALG instrument is an on-line assessment tools used by faculty to ask students a variety of

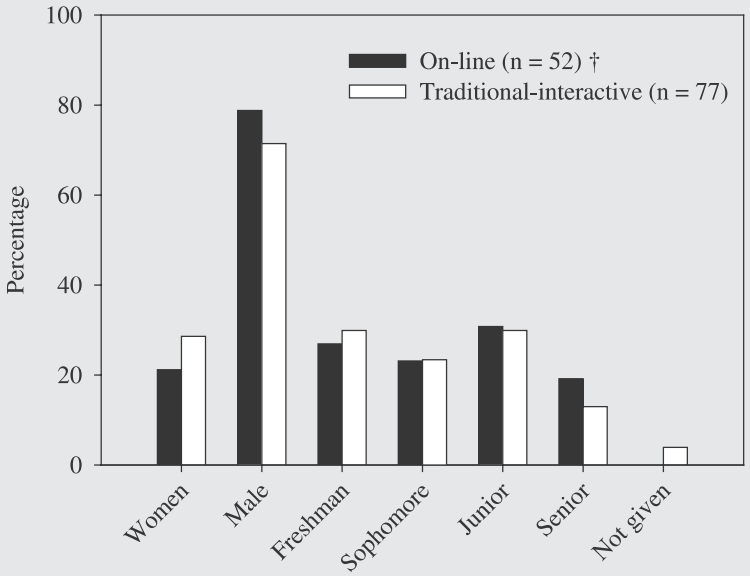

Fig. 1- Gender and class standing percent distribution of the groups that utilized the traditional-interactive and on-line soil ersosion lesson in an introductory Soil Science course. † Demographics of three out of the 55 students on-line participants were not available.

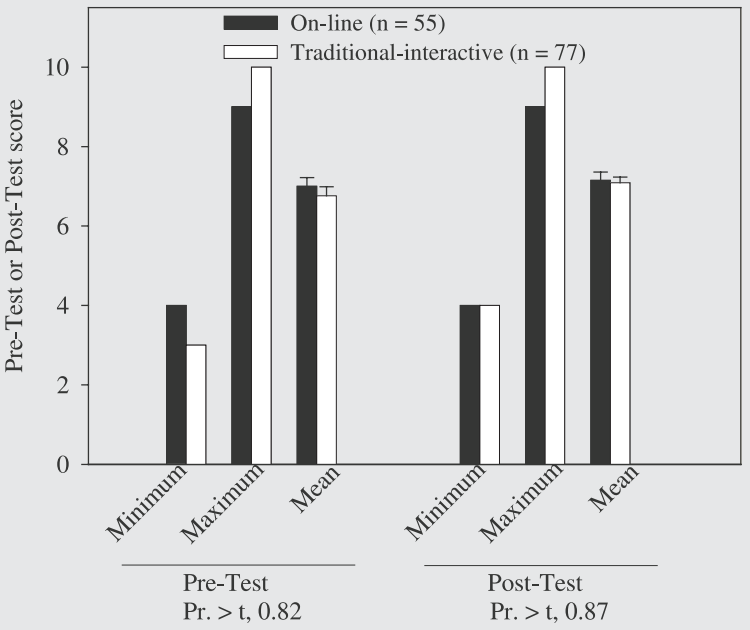

Fig. 2- Comparison of test scores between students who used the traditional-interactive and on-line soil erosion lesson in an introductory Soil Science course.

questions related to student gains in learning. Through an on-line survey, students are asked to select statements of agreement or disagreement in relation to skill development, cognition, and their attitudes toward the subject being studied within the course (Seymour, 1997). The survey instrument used for this study included six categories students rated on a degree of gain on a 1-to-5 Likert-type scale responding to the stem, "How much did each of the following aspects of the class help your learning:" Ratings indicate 5=best, 1=worst. Specific categories used from the SALG instrument in this study can be found in Table 1. A Cronbach alpha level of .97 was computed, thus determining the instrument to be acceptably reliable (Gravetter and Wallnau, 1996).

Pre- and post-tests scores and SALG survey data were statistically analyzed using SAS Version 8 (Statistical Analysis System, 1999) for differences between experimental group means using a t-test with a significance level set at 5%.

Table 1- Summary of results of Student Assessment of Learning Gains (SALG) survey comparing traditional-interactive and on-line erosion lessons. (Response levels; 5=best, 1=worst.).

Item	On-line Mean (n=55)	Traditional Mean (n=77)	Pr >|t|
How much did information you were given about this module help your learning?			
1. Preparation for the erosion module.	3.32	2.96	0.06
2. The teacher provided support for this module on erosion.	3.74	3.69	0.75
How much did each of the following aspects help your learning?			
3. The way in which the material was approached.	3.73	3.47	0.02
4. The pace at which we worked.	3.73	3.24	0.00
5. Ability to proceed through section of the lesson	3.96	3.49	0.00
6. Participation in the lesson and preparation for the test.	3.83	3.33	0.00
7. The fairness of test content as related to erosion.	3.67	3.35	0.03
8. The mental stretch required to complete the lesson.	3.64	3.21	0.00
9. The grading system used in this lesson.	3.62	3.32	0.03
10. The feedback received from this lesson.	3.55	3.02	0.00
How much has this module added to your skills in each of the following?			
11. Identifying the initial signs of erosion.	3.60	3.44	0.30
12. Selecting appropriate solutions to the various types of erosion.	3.71	3.50	0.05
How much did resources provided help your learning with respect to the following:			
13. The overall cause of erosion.	4.02	3.42	0.00
14. The impact of water on erosion.	4.07	3.51	0.00
15. The water erosion process.	4.07	3.51	0.00
16. The impact of wind on erosion.	3.87	3.53	0.01
17. Understanding the factors effecting wind erosion.	3.96	3.44	0.00
18. Understanding the control of wind erosion.	3.80	3.36	0.00
19. The effects of erosion.	3.96	3.69	0.04
20. Understanding the factors enhancing soil erosion.	3.98	3.45	0.00
21. Estimating soil erosion from fields using USLE.	4.04	3.25	0.00
22. The overall perception of this lesson on erosion.	4.06	3.44	0.00
Because of the lesson, how well do you think you now understand each of the following?			
23. Ability to differentiate between geologic and accelerated erosion.	4.05	3.83	0.25
24. Ability to describe the mechanisms of soil erosion.	3.98	3.44	0.00
25. Ability to describe four types of water erosion.	3.73	3.39	0.04
26. Ability to describe each of the six factors affecting soil loss appropriate for a given situation.	3.56	3.13	0.03
27. Ability to locate values for each of the six factors affecting soil loss appropriate for a given situation	3.38	3.17	0.30
28. Ability to calculate soil loss from water erosion from the USLE.	3.57	3.28	0.22
29. Ability to determine suitable values for one of the six soil loss factors if allowable loss and values of the other five factors are known.	3.57	3.41	0.34
30. Ability to describe the three types of wind erosion and describe the five factors that affect the amount of soil lost by wind erosion.	3.75	3.17	0.00
31. Ability to identify particle size ranges which are susceptible to each of the three types of wind erosion	3.98	3.52	0.00
32. Ability to identify whether wind, water, or both kinds of erosion are likely problems when given a field erosion situation.	3.89	3.67	0.15
33. Ability to select erosion control measures for a field situation.	3.84	3.60	0.14
To what extent did you make gains in the following as a result of this lesson?			
34. Understanding the main concepts of erosion.	3.93	3.61	0.01
35. Understanding the relationship between factors contributing to soil erosion.	3.91	3.57	0.00
36. Understanding how ideas in this lesson relate to those in other classes.	3.90	3.40	0.00
37. Understanding the relevance of this module to real world issues on erosion.	3.81	3.70	0.29
38. Appreciating soil management and conservation.	3.83	3.69	0.23
39. Ability to think through a problem or argument related to erosion.	3.82	3.48	0.04
40. Confidence in your ability to address issues and problems related to erosion.	3.76	3.44	0.03
41. Feeling comfortable with complex ideas related to erosion.	3.64	3.19	0.01
42. Enthusiasm for soil management and conservation.	3.49	3.28	0.13
43. Understanding the major components, causes, and prevention measures associated with erosion.	3.71	3.43	0.05

Results and Discussion

Student academic majors for participants in both semesters consisted largely of Agronomy, Horticulture, Fisheries and Wildlife, Mechanized Systems Management, Animal Science, Agricultural Education, and Agricultural Business. Other majors not present in significant numbers were Natural Resources Science, Environmental Studies, Psychology, Elementary Education, and Grazing Livestock Systems. Student demographics, with respect to distribution of majors, gender, and academics class were similar between semesters (Figure 1). Pre-test and post-test scores were not statistically different between traditional-interactive and on-line teaching methods (Figure 2). The similarity in post-test scores suggests that the on-line lesson is equally effective in helping students master learning objectives as the small group method. Wegner et al. (1999) also found no significant difference in student test scores between the traditional-interactive teaching similar to this study and internet-based instruction.

Students using the on-line lesson gave average responses to questions on the SALG survey that were significantly more positive in four out of six categories of questions, and to 31 out of 43 questions overall (Table 1). On no question or category were average students responses from the traditional-interactive approach more positive than those from the on-line. This positive perception by students may be associ-

ated with the fact that students are in control of determining the direction and sequence of their own learning (Lu and Molstad, 1999).

In the traditional setting, the instructor has the responsibility of providing and maintaining motivation (Guzley, 2001).

The ratings on resource availability (textbook assigned reading, instructor, review questions) were similar between teaching methods (Questions 1 and 2). Students consistently evaluated the design of the on-line lesson more highly than the traditional-interactive lesson (Questions 3 to 10). Specifically, students who utilized the on-line lesson rated their working pace (i.e., not being rushed by group members) higher than the students who used the traditional-interactive lesson. Also, students who used the on-line lesson rated their participation higher than those who used the traditional-interactive lesson (Question 6). The higher score on the participation question of the on-line lesson may be associated with self-motivation enhanced by the interactivity of the on-line lesson. This motivation may reinforce students' need to be accountable for their own learning and may encourage them to be more active learners. Guzley et al. (2001) have also observed a significant positive relationship between student motivation and class participation using a computer-mediated video instruction.

There was no difference in perceived skills gained between the two teaching methods (Questions 11 and 12). This is consistent with the similar results of the post-tests given to both student groups. With regard to "availability of resources to help in students' learning" (Questions 13-22), students who used the on-line lesson gave a consistently higher score than students who used the traditional-interactive lesson. In particular, students had a score of 4.04 for the on-line lesson vs. 3.25 for the traditional-interactive lesson in estimating the amount of soil lost using the USLE (Question 21). The quantitative interactive USLE model used as a resource in the on-line lesson possibly contributed to the higher score in this particular question. The availability of this resource within the on-line lesson allowed students to assess the effect of their own management decisions on soil erosion. The inclusion of simulation models as an online teaching resource is especially valuable to promote student knowledge on complex processes eliminating the need to conduct complex experiments that are both time consuming and expensive (MacKenzie et al, 2001).

With regard to understanding soil erosion, the on-line teaching method score was higher than the traditional-interactive lesson for only five of 11 questions (Questions 23 to 33). The similar scores between the teaching methods were in the areas of differentiating accelerated vs. geologic erosion, manipulating the USLE factors and equation, identifying the likely erosion force, and selecting erosion control measures. Overall, students who utilized the on-line lesson evaluated their understanding of the soil erosion process, soil erosion factors, management and environmental conditions inducing erosion, and solutions to controlling erosion more highly. Seven of the 10 questions (Questions 34 to 43) describing learning gains were evaluated more highly by the group using the on-line teaching method when compared to those using the traditional-interactive lesson. Relevance of the lesson to real world issues, the appreciation of soil management, and student enthusiasm for soil management and conservation were similar between the two teaching methods. Non-quantitative comments of some students also indicate the acceptance of the on-line lesson (Figure 2).

While learning gains are critical components of the teaching and learning process, students who utilized the on-line lesson found many areas in need of improvements (data not presented). There is a need to improve the design of the on-line lesson to accommodate various learning preferences of students. The availability and quality of on-line support for individual learners who encounter areas of difficulty was another area requiring improvement. A few students preferred the ability to incorporate self-selected options within the

Figure 2-Comments regarding the on-line soil erosion lesson made by introductory Soil Science students on the SALG survey.

I love the change in learning to more of a visual aspect. Plus, the equation and the actual complexity of the program surprised me. I would like access to it to evaluate some of my farm.

I liked the on-line approach because it gave me more freedom to move at my own speed, which is usually faster than that chosen by others.

I like to be able to work at my own pace, and not be hurried by others.

The explanations were clear and informative. The interactive video helped visualize the concept of wind erosion and the USLE helps up see what factors effected erosion and why.

On-line is better than working out of a book
I really liked the vivid pictures and animations. I found them to be very helpful.

The lesson really did show what a big problem erosion is and its effects on production. Also how much erosion can vary from a certain practice to the next erosion control practice.

The on-line lesson was definitely a good thing. More lessons like this would also be helpful

I have really enjoyed this part of the class. It is something that I will be dealing with in my current and future employment.

lesson to allow them to navigate and maneuver within and between the various sections. In the area of instructional design, many students referenced the need to ensure that content within the various sections correctly matched the assessment instrument (post-test).

Conclusions

The Student Assessment of Learning Gains survey found that students who participated in the on-line lesson stated the strongest support for the design of the class activities, and the way the lesson was delivered. With proper implementation of instructional design and technical support, incorporation of on-line lessons into the curriculum and classrooms of college and university level soil science classes is an effective way to enhance student interest, motivation, and satisfaction in the learning process. The results of this study indicate that the use of on-line-interactive technologies would be widely accepted by the current generation of university level introductory soil science students.

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