TEACHING SOIL CONSERVATION IN AN INTRODUCTORY SOIL SCIENCE LABORATORY AND THE CLASSIFICATION OF EXAMINATIONS USING THE REVISED BLOOM'S TAXONOMY

By

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TEACHING SOIL CONSERVATION IN AN INTRODUCTORY SOIL

SCIENCE LABORAROTY AND THE CLASSIFICATION OF

EXAMINATIONS USING THE REVISED BLOOM'S TAXONOMY

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NOMENCLATURE

cm	centimeter
g	gram
in	inch
IRB	Internal Review Board
m	meter
mm	millimeter
NRCS	Natural Resources Conservation Service
PVC	Polyvinyl Chloride
USDA	United States Department of Agriculture
USLE	Universal Soil Loss Equation
WEQ	Wind Erosion Equation
yr	year

CHAPTER I

INTRODUCTION

Soil Erosion by Water and Wind

Soil erosion by water and wind affects 1.64 billion hectares globally which accounts for 83% of land degradation (Oldeman et al., 1991). Annually, global soil loss by water erosion is estimated at 67 billion metric tons year^{-1}, which is approximately 52% of global, annual erosion (Reich et al., 2005). Soil loss from water and wind erosion is primarily attributed to a combination of deforestation, overgrazing, and agricultural mismanagement, which disrupts the structure and vegetative cover of the soil (Oldeman et al., 1991). Without human interference, the rate of geologic erosion varies from 0.0001 to 0.01 mm/yr for gently sloping lowlands, 0.001 to 1 mm/yr for moderate gradient hillslopes, and 0.1 to greater than 10 mm/yr for steep, tectonically active alpine topography. Rates of erosion for the lowlands and hillslopes are in equilibrium with soil formation, which occurs at an average rate of 0.036 mm/yr. In contrast, erosion from conventionally farmed agricultural land occurs at rates similar to those seen in the alpine area. However, it should be noted that rates of soil erosion and formation vary widely depending on climate, soil composition, topography, and vegetative factors (Montgomery, 2007).

Detrimental effects of water and wind erosion include the loss of agricultural productivity, eutrophication, sedimentation of bodies of water, desertification, and air pollution. These problems can be mediated through conservation oriented, land management including implementation of conservation tillage, contour cropping, strip cropping, terraces, and shelter belts (Eswaran et al., 2001). Implementation of these practices has been promoted through the efforts of multiple agencies including the Soil Erosion Service, which became the Soil Conservation Service and then, the Natural Resources Conservation Service (NRCS). The Soil Erosion Service encouraged soil conservation practices through cost sharing programs, by educating the public about conservation technologies, and through demonstration projects (Helms, 1990). The net effect of these programs is difficult to estimate due to variance between soil erosion models (Trimble, 2000). However, cropland erosion estimates conducted by the United States Department of Agriculture (USDA) reported a decrease in total soil erosion in the U.S. from seven billion metric tons in 1982 to five billion metric tons in 1992 (Reich et al., 2005). Regardless of the accuracy of the USDA's estimate, the majority of studies and estimates of U.S. erosion agree that erosion continues to represent a serious environmental problem that requires continued research and attention (Trimble, 2000).

Experiential Learning

Experiential learning has its foundation in John Dewey's (1938) book, *Experience and Education* (Kolb, 2005; Roberts, 2003). In this book, Dewey outlined the meaning and effects of educational experiences. Dewey stated that all methods of teaching provide an experience, but the goal of education is to present information in such a way that the experience prepares students for future experiences of a similar nature and does not impair students' desire to engage in such future experiences. These experiences are not only affected by their presentation, but they are subject to the prior knowledge and beliefs of the student (Dewey, 1938). Experiential learning theory is subject to wide and ongoing interpretation from multiple sources and is often interpreted as part of experiential education, service learning, and progressive education (Association for Experiential Education, 2010; Roberts, 2003; Warren et al., 1995; Washbourn, 1996). It has come to describe multiple activities from kinesthetic-directed instruction to special projects coupled with reflection to team building adventures in the wilderness (Fenwick, 2000). Such activities stand in contrast to the passive learning which occurs when students are not actively involved in the material (Bergsteiner et al., 2010).

Kolb's (1984) theory of experiential learning is one of the most influential in the field and has been cited by over 1000 studies in educational fields (Coffield et al., 2004). There six tenets in Kolb's theory that encompass many of the theoretical foundations from alternate sources.

1. Education is a process, and educators should seek processes that enhance the learning of their students.
2. The process of learning is facilitated when students' prior experiences and beliefs are drawn into the learning process and examined within that process.
3. Learning requires the learner to act and reflect upon his/her actions in order to resolve conceptual conflicts.
4. Learning is not just an abstract mental process. Rather it is a holistic process in which the learner must think, feel, perceive, and behave.
5. Learning occurs through interaction with the environment. This interaction should assimilate new experiences with former experiences.
6. Learning is not a process in which knowledge is simply transmitted to a student, but it is a process in which the student creates new knowledge (Kolb, 2005).

These tenets provide a wide base of potential applications, examples of which are discussed in the following section.

Experiential learning can take place in the classroom as an integrated part of daily curriculum. For instance, Groves et al. (2010) created a module which helped students cultivate study skills. During this module, students received a 30 minute lecture over a skill at the beginning of class, and then, they utilized that skill during the remainder of the period (Groves et al., 2010). Canu (2008) used experiential learning as an introduction to a unit on fear by stimulating students' anxiety responses. Students were asked to look at a series of pictures and rank their levels of anxiety; these rankings were used during discussion for the remainder of the unit.

Experiential learning can be used to simulate real world situations within the context of a safe, learning environment. Seed (2008) used team-building exercises at a ropes course to provide groups of pre-service teachers with the experience of working as a team. Dolan and Stevens (2006) implemented a program for senior level economic students in which students actively engaged in economic analysis and forecasting activities which simulated real world business skills (Dolan and Stevens, 2006).

Finally, experiential learning can be used in curriculum which takes learners away from the classroom in order to immerse them in an experience. Romi and Lev (2007) created a trip to Poland which taught students about the Holocaust by immersing them in a "cognitive-emotional experience." Experiencing the Jewish culture and Holocaust artefacts first hand improved students' knowledge and altered their attitudes toward the Holocaust as evidenced on multiple surveys (Romi and Lev, 2007). Handler and Duncan (2006) invited students to participate in a five-day educational program. During the course of the program, students attended seminars and participated in capturing, tagging, and recording data on hammerhead sharks (Handler and Duncan, 2006).

Thus, application of experiential learning is widely varied in methods of application and subject matter. However, these articles had the commonality of providing tactile experiences in which learners could interact with subject matter.

Research Tools

This experiment utilizes surveys and quizzes for collecting data on student opinions and knowledge. The basic form of a survey is a series of questions which elicit opinions or beliefs from the respondent. Surveys can provide a simple way to collect accurate information in a form which is easy to analyze. Well constructed surveys have many requirements. They should have short, clear instructions and questions which take no more than twenty minutes to complete. There should be a minimal number of open-ended questions, which require the most thought and time, to reduce the risk of questions left blank. If open ended questions are present, they should be placed at the end of the survey to allow respondents to comment on items that have not been addressed in the previous sections of the survey (Wilkinson and Brimingham, 2003). Surveys should have a well defined purpose and avoid negative wording such as "Circle the items which you did NOT enjoy." Attention must be given to using vocabulary appropriate for respondents, using examples of potentially confusing terminology, organizing questions in a logical sequence, and avoiding question statements which could lead to acquiescent responses such as "In light of increasing criminal activity, do you believe that the law enforcement budget should be increased?" Surveys should be piloted, if possible, to receive feedback on clarity and structure (Mertens, 1998).

This experiment utilizes a Likert-scale survey. Likert-scale surveys measure the attitudes of respondents by providing a scale of responses from very positive to very negative for set statements. For instance, a scale may range from "strongly agree" to "strongly disagree" with set statements such as "I dislike having my cell phone turned off." Scaled responses are generally coded into numbers for analysis; for example, “strongly agree” would be coded as one, “agree” as two, and “neutral” as three. Average group scores for these coded responses are used in analysis (Wilkinson and Brimingham, 2003).

Tests provide a standardized method to assess student learning through a series of questions. Like surveys, well constructed tests have many requirements. Tests should have clearly defined objectives and existing tests with similar objectives should be used to select question format and content. If possible, questions should have a single format, multiple-choice, short answer, or essay. Vocabulary should be at an appropriate level for respondents. Tests should be reviewed by people knowledgeable in the content area and trial tested by people similar to the group which will receive the final test (Norman and Fraenkel, 2001).

Soil Conservation Education

Although there are multiple examples of soil conservation lesson plans available in scientific literature or through internet resources such as the NRCS website, the majority of these lesson plans do not have accompanying reports which validate their efficacy (Conservation Education Materials, 2010; Degani et al., 1979; Dickinson et al., 1990; Huber and Falkenmayer, 1987; Pierson, 1961; Stetsko, 1994). Some, however, offered anecdotal evidence of their efficacy (Dillaha et al., 1988; Haigh and Kilmartin, 1987; Hagmann et al., 1997). Only one study was found in which two methods of teaching soil conservation were compared and tested (Mamo and Kettler, 2004). These articles suggested varying methods of teaching soil conservation. Some suggested the use of computer simulations (Degani et al., 1979; Dickinson et al., 1990; Huber and Falkenmayer, 1987; Mamo and Kettler, 2004). Others suggested the use of rainfall or erosion simulators (Dillaha et al., 1988; Haigh and Kilmartin, 1987; Hagmann et al., 1997). Only two of the nine articles offered lesson plans pertaining to wind erosion; these articles suggested either short, hands-on wind erosion experiments or long-term observations of the effects of wind erosion (Stetsko, 1994; Peirson, 1961).

Mamo and Kettler (2004) compared the efficacy of an on-line soil erosion lesson to a worksheet lesson. Thirteen learning objectives were created which were covered in both lessons. Students completed a pre-test and a post-test; both were multiple choice tests which were based on the learning objectives. Students also complete a survey which surveyed students' opinions about their learning gains. Pre-test and post-test scores were not significantly different between groups. Students in the on-line soil erosion group reported more positive perceptions of the lesson than the worksheet group.

Experimental Goals

In this experiment, two experiential methods of teaching soil conservation are tested. In the first method, students receive a lecture and engage in small group activities; in the second, students use a rainfall simulator and wind tunnel. Both methods involve tactile experiences in which the students interact with the material. However, the use of the rainfall simulator and wind tunnel provide an increased level of interaction between the students and the material by removing them from the classroom and allowing them to interact with large-scale simulators. The goal of this experiment is to determine whether students who complete the large-scale simulator activity perform better on quizzes and have more positive opinions of the laboratory activity than students who receive the lecture and engaged in small group activities.

MATERIALS AND METHODS

I. Design

This experiment was conducted in two trials over two semesters with procedural modifications occurring during the second semester. Therefore, the materials and methods section is divided into methods used for the first semester and methods used for the second semester. The first trial occurred during the Fall of 2009, and the second trial occurred during the Spring of 2010.

II. Trial One: Fall 2009

Ten learning objectives were identified from material in the assigned soil science textbook, The Nature and Properties of Soil (Brady, N. and Weil R., 2008). Learning objectives included understanding of the following:

1. Definition of erosion
2. Spiral of soil erosion (Figure 1)
3. Three types of water erosion
4. Detrimental effects of water erosion
5. Factors of Universal Soil Loss Equation (USLE)
6. Tools to control water erosion
7. Three types of wind erosion
8. Detrimental effects of wind erosion
9. Factors of the Wind Erosion Equation (WEQ)
10. Tools to control wind erosion

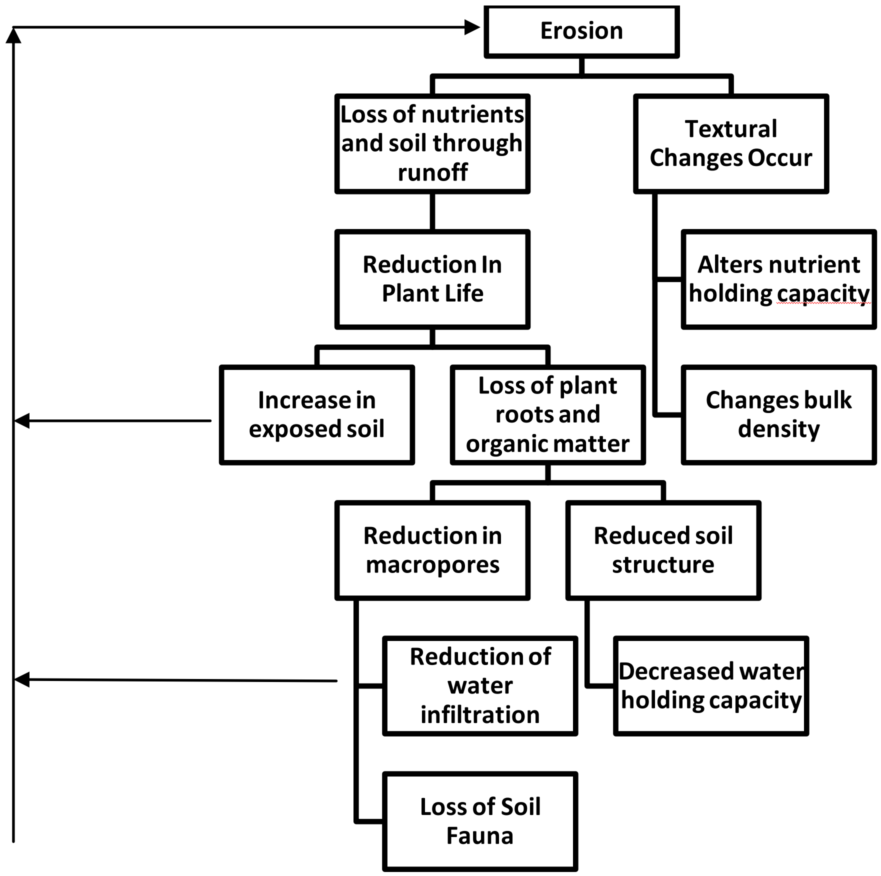

Figure 1. Flowchart used to describe the spiral of soil erosion. The figure was presented in the Lecture Group's PowerPoint presentation and Simulator Group's laboratory handout.

A laboratory exercise was developed in two delivery formats, which covered the ten, soil erosion learning objectives, designated as the Lecture Group and the Simulator Group. For the Fall 2009 semester, six sections were divided into two groups, the Lecture Group and Simulator Group, using a random number generator to create an equal number of laboratory sections in each group. To maintain consistency of instruction, a single instructor taught all six, laboratory sections during the week of the experiment. Before students participated in their laboratory groups, students were asked to sign an informed consent form as part of the Internal Review Board (IRB) process during their normal lecture period. Students were informed that all students would participate in the laboratory regardless of their participation in the study and that none of the quizzes pertaining to soil conservation would affect the students' final grades.

A ten question, multiple-choice pre-test based on the ten learning objectives was given during the same lecture period in which students were asked to sign the informed consent form (Table 1).

Students in the Lecture Group received a PowerPoint lecture covering all ten learning objectives with notes to be filled in, participated in small group activities, and performed post-laboratory calculations and questions during their two hour, laboratory period. Small group activities, which tested two factors of the USLE, the climate and slope factors, were performed directly after the portion of lecture that described factors of the USLE. This was done to break up the lecture and keep students engaged in the material. During small group activities, students used a soil erosion box (Figure 2). With the erosion box, students tested the effect of low intensity rainfall, high intensity rainfall, and increased slope. Post-laboratory calculations and questions were taken from the laboratory manual assigned for the class. Post-laboratory calculations required students to calculate predicted soil loss with varying factors of the USLE. There were eight post-laboratory questions, not including the calculations (Hattey and Patton, 1996).

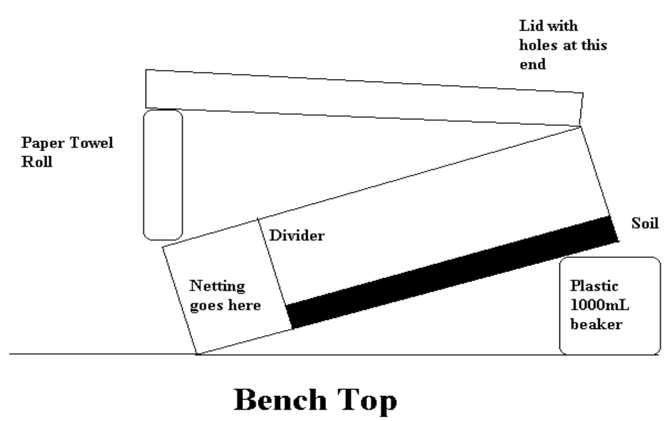

Figure 2. Soil erosion box used to test slope and climate factors of the USLE.

Table 1. Pre-Test questions corresponding to the ten learning objectives.

Learning Objective	Pre-Test Question
1	Erosion is the ________, _________, and __________ of soil material. a. Transport, deposition, detachment b. Deposition, detachment, transport c. Detachment, transport, deposition
2	Which of the following statements is **false**? a. Loss of plant roots leads to a reduction of water infiltration. b. The loss of soil fauna will decrease the water holding capacity of the soil. c. Erosion can change the texture of surface soils.
3	The three types of water erosion are ______, ______, and _________. a. Sheet, rill, gulley b. Saltation, rill, gulley c. Drift, creep, row
4	Erosion by water can cause ____________. a. Aminization b. Eutrophication c. Solarization
5	In the universal soil loss equation A = RKLSCP, C stands for a. Cropping factor b. Climate factor c. Incline factor
6	One of the ways that contour, strip cropping reduces runoff is by ________. a. Reducing erodibility b. Capturing sediment c. Running parallel to the slope
7	Medium sized soil particles will generate this type of wind erosion. a. Creep b. Saltation c. Suspension
8	Movement of fine particle by wind erosion _________. a. Reduces soil fertility b. Accounts for 50% of erosion c. Can only travel short distances
9	For the wind erosion equation, E=f(ICKLV), I stands for a. Incline b. Climate c. Erodibility
10	Which of the following statements about vegetation buffers is **false**? a. They will cause wind to move upward temporarily b. They capture suspended sediment c. They will increase soil crust formation

The Simulator Group received a laboratory handout containing background information that covered the ten learning objectives, procedures for the use of the rainfall simulator and wind tunnel, post-laboratory calculations, and post-laboratory questions (Appendix I). The Simulator Group was taken to the agronomy farm on the Oklahoma State University campus to use the rainfall simulator (Appendix II).

The rainfall simulator consisted of five treatment boxes. Treatments were bare soil that was tilled, bare soil with terraces, bare soil with strip cropping, bare soil with straw residue on the surface, and a grassed treatment. The bare, tilled soil treatment was created by removing weeds and tilling using a gardening fork. Terraces were created by hand. Strip cropped treatments were created using *Cynodon dactylon* sod cut into to strips which were laid parallel to each other with bare soil in between. The grassed treatment was created by seeding *Festuca arundinacea*. Treatments illustrated the cropping and support practices of the USLE.

Figure 3. Grassed, bare tilled soil, and terraced treatments for the rainfall simulator after several simulated rainfalls.

Students were divided into five groups corresponding to the five treatments. Runoff water was collected as it traveled off the plots through a spout attached to the treatment boxes. While the rainfall simulator was running, the instructor discussed the portions of the handout related to erosion by water. When enough time had passed to collect an adequate amount of runoff from all treatments, the simulator was turned off. Students compared the impact of rainfall on the plots and compared runoff samples. In the laboratory, students filtered and weighed sediment samples from the rainfall simulator. They used data collected to calculate tons of soil loss (tons acre^{-1}).

Upon completion of the rainfall simulator activity, students were driven to the Agricultural Engineering laboratory on the Oklahoma State University campus to observe processes and impacts of wind erosion in a wind tunnel. Four treatments were established in the wind tunnel on 60.96 cm X 10.16 cm (24 inch X 4 inch) polyvinyl chloride (PVC) pipes, which were cut in half and attached to 5.08 cm (2 inch) tall pieces of wood. The PVC channel was attached to the wood in order to allow sand to roll off the PVC channel into a sand trap. Four treatments included bare sand, sand with a windbreak, bare organic soil, and organic soil with a windbreak (Figure 4). Treatments were created by adding either sand or topsoil to the PVC pipes and attaching leaves of *Juniperus virginiana* to treatments requiring a windbreak. These treatments illustrated the soil ridge roughness factor and the vegetation factor of the WEQ. Students observed the treatments in the wind tunnel; they were asked to note energy transfer from wind to windbreak and the movement of both types of soil. During this time, the instructor discussed portions of the handout pertaining to wind erosion. Sediment was collected using a sand trap in the wind tunnel with sediment weight recorded by the students. After the wind tunnel portion of the laboratory was complete, students returned to their normal laboratory classroom in Agriculture Hall. After filtering and weighing their sediment from the rainfall simulator, students performed post-laboratory calculations and questions pertaining to both water and wind erosion.

Figure 4. Two of four wind tunnel treatments for the Fall 2009 semester, bare sand and organic soil with a windbreak.

Two, five question quizzes were created which covered the ten learning objectives in order to assess the effectiveness of the Lecture Group and Simulator Group (Table 2). A 19 question survey was also created to assess students' self-reported beliefs of their understanding of the learning objectives as well as their opinions on the value of information learned during their laboratory and their enjoyment of the laboratory (Table 3). The students rated the first 16 questions on the survey based on a Likert-type scale from one to five where one was No, Definitely Not, five was Yes, Definitely, and three was Neutral. The first quiz and survey were administered one week after the completion of the laboratory. The second quiz was administered five weeks after the completion of the laboratory.

Six weeks after the completion of the Simulator Group and Lecture Group laboratory exercises, the laboratory groups were switched in accordance with the IRB. The Lecture Group completed the Simulator Group laboratory and vice versa. This was done to allow students both learning experiences so that neither group would be disadvantaged during the final exam.

Table 2. Questions from quizzes one and two from the Fall 2009 semester corresponding to the ten learning objectives.

Learning Objective	Quiz Number	Quiz Question
1	1	Which part of the definition of erosion is most heavily affected by raindrop impact and saltating particles? a. Transport b. Detachment c. Deposition
2	1	Name two ways in which long term water erosion decreases soil organic matter.
3	1	________are the most damaging types of soil water erosion. a. Rills and gullies b. Sheets and rills c. Gullies and sheets
4	2	If a body of water frequently receives runoff from agricultural land, it can be reasoned that there will be __________. a. Fish kills resulting from lower bio-available oxygen. b. Eutrophication resulting from riparian buffer strips. c. Algalation resulting from fertilizer runoff.
5	2	The P factor in A=RKLSCP will result in less water erosion when ______. a. The intensity of rainfall decreases b. Terraces are put into place. c. The silt content in the soil decreases.
6	2	Which of the following treatments will likely have the least water erosion? a. A corn field that has been conventionally tilled b. A corn field with terraces c. A corn field under no-till production
7	2	Which type of wind erosion will result in the greatest loss of cation exchange capacity for a soil?
8	1	List two detrimental effects of wind erosion.
9	1	For the wind erosion equation, E=f(ICKLV), the K factor predicts greater erosion by wind ___________. a. When the erodible fraction is increased b. When prevailing winds are above 15 mph c. When the soil surface is smoother.
10	2	Increasing soil organic matter is important to decreasing wind erosion because it ___________. a. Increases aggregate stability b. Decreases the erodible fraction of the soil texture c. Promotes crust formation

Table 3. Survey one from the Fall 2009 semester.

Question Number	Survey One Question
1	Do you feel that you learned a lot during this lab?
2	Do you understand the definition of erosion?
3	Do you understand the impact of erosion on civilization?
4	Can you differentiate between the three types of water erosion?
5	Do you understand how erosion causes a spiral of soil degradation?
6	Do you understand the detrimental effects of water erosion?
7	Do you know the factors of the Universal Soil Loss Equation?
8	Do you understand the tools for controlling water erosion such as strip cropping?
9	Can you differentiate between the three types of wind erosion?
10	Do you understand the detrimental effects of wind erosion?
11	Do you know the factors of the Wind Erosion Equation?
12	Do you understand the tools for controlling wind erosion such as vegetation buffers?
13	Is the information you learned from this lab important to your life outside of academics?
14	Do you believe that the information from this lab will be useful in your future studies?
15	Was the information you learned today appropriate for an introductory soils class?
16	Did you enjoy this lab?
17	Please write two things you liked about the lab.
18	Please write two things you dislike about the lab.
19	Please add any additional comments in the space below.

III. Trial Two: Spring 2010

Trial two modified the materials and methods procedures from trial one. Modifications noted in this section were created as a result of instructor observation and preliminary analysis of trial one results. The learning objectives remained the same as did the pre-test. However, on the day that the pre-test was administered, the students received an in class, PowerPoint lecture that covered five of the ten learning objectives. This was done to reduce the amount of material that needed to be covered in laboratory. Learning objectives covered during the in class lecture were:

1. Definition of erosion
2. Three types of water erosion
3. Detrimental effects of water erosion
4. Three types of wind erosion
5. Detrimental effects of wind erosion

The laboratory sections were partially assigned using a random number generator, but because there were seven laboratory sections, the remaining section was used to balance the number of participants in the Lecture Group versus the Simulator Group.

The Lecture Group procedures were modified by shortening and altering the PowerPoint presentation from trial one, creating additional small group activities, and altering post-laboratory questions. PowerPoint slides pertaining to the learning objectives covered during the in class lecture were removed, and there were several other small edits to help clarify material in the presentation. Treatments were added to small group activities to test additional factors of the USLE. In addition to climate and slope factors tested during trial one, students tested cropping and support practice factors. These factors were tested by adding a terrace treatment and a cropped treatment to the erosion boxes. The “crop” was created by using small, plastic plants. Instead of instructions being given verbally for the use of the erosion boxes, a handout was created (Appendix III). Lastly, while post-laboratory calculations taken from the laboratory manual remained the same, post-laboratory questions were rewritten to create a greater emphasis on wind erosion.

The Simulator Group's laboratory handout was shortened to cover only the learning objectives not covered during the in class lecture (Appendix IV). The procedures for the rainfall simulator remained the same. However, the rainfall simulator was brought to Agricultural Engineering Laboratory to eliminate driving time. This provided additional time for students to complete post-laboratory calculations and questions. Treatments for the wind tunnel were changed to create additional examples of the factors of the WEQ. Treatments were selected by emulating agricultural practices or their effects. All of the treatments used sandy soil. There were six treatments; these included sandy soil with terraces, a crust, organic matter, a windbreak, perpendicular cropping, and perpendicular cropping with residue on the surface (Figure 5). The organic matter treatment was created by spraying the sand with a mixture of sugar and water. These treatments illustrated the erodibility, soil ridge roughness, and vegetation factors of the WEQ. Instead of students simply observing these plots as in trial one, the student groups from the rainfall simulator were assigned wind erosion treatments and asked to participate in the creation of those treatments. This was done to improve the hands-on nature of the experiential learning within the experiment. Only two groups at a time were asked to use the wind tunnel while the remaining groups worked on post-laboratory questions in another room. Thus, the instructor covered the information from the handout pertaining to wind erosion with small groups rather than with the whole laboratory at once. This was done to compensate for the loud noise and small room size of the wind tunnel room. Post-laboratory calculations underwent slight modifications to improve clarity. Post-laboratory questions were altered to create a greater emphasis on wind erosion.

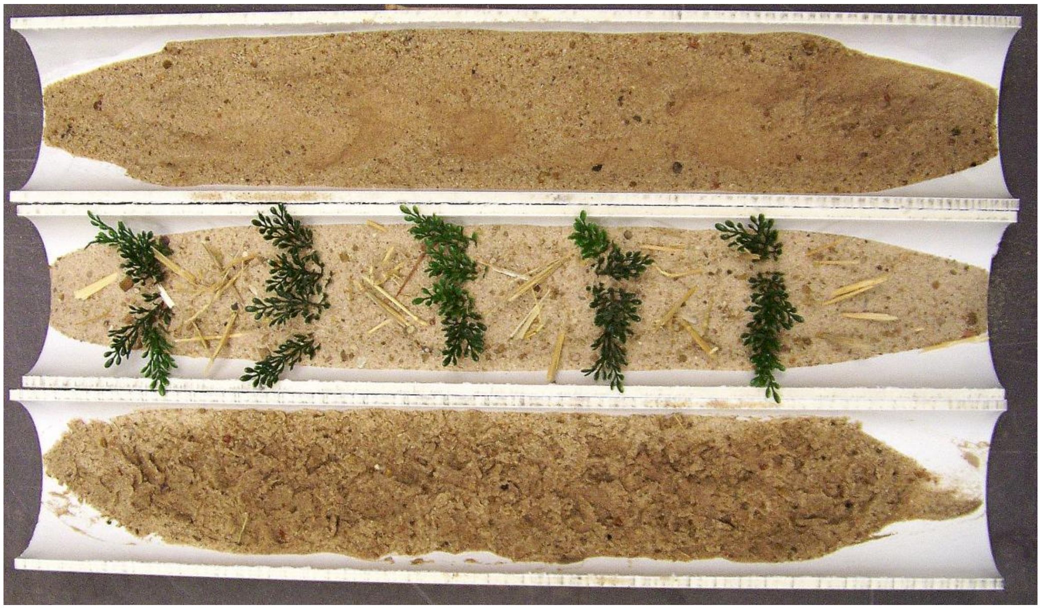

Figure 5. Wind tunnel treatments. From top to bottom: sandy soil with a crust, sandy soil with perpendicular cropping and residue, sandy soil with a sugar spray acting as organic matter.

Both five question quizzes were extended to cover the ten learning objectives (Table 4). As in trial one, the first quiz was administered one week after the completion of the laboratory and the second quiz four weeks after the first quiz. Survey one remained the same and was administered one week after the completion of the laboratory. An additional survey was administered after the laboratory sections switched groups. The second survey contained the first 16 questions of survey one, but rather than ranking how well the laboratory had performed, students were asked to select a preference for either the Lecture Group, the Simulator Group, or neither.

Table 4. Additional questions from quizzes one and two from the Spring 2010 semester corresponding to the ten learning objective.

Learning Objective	Quiz Number	Quiz Question
1	2	Which of the following transports of soil would fall under the definition of erosion? a. Water, wind, and gravity b. Water, wind, and bulldozers c. Water, wind, ice, and gravity
2	2	The spiral of soil erosion begins with ___________. a. Nutrient loss b. Loss of soil fauna c. Decrease water holding capacity
3	2	List the three types of water erosion.
4	1	Which of the following is a detrimental effect of water erosion? a. Sedimentation b. Saltation c. Salinization
5	1	Changes in the LS factor in A=RKLSCP has the potential to ______________. a. Decrease raindrop impact b. Decrease water velocity c. Decrease soil cover
6	1	Increasing ___________ will increase a soil's resistance to erosion. a. Silt content b. Soil crust c. Aggregate stability
7	1	______ is the detaching agent for wind erosion. a. Suspended particles b. Saltating particles c. Creeping particles
8	2	Prolonged wind erosion can lead to ______________. a. Eutrophication b. Desertification c. Filling in of lakes and streams
9	2	What do factors L and V represent in the wind erosion equation?
10	1	Wind erosion is problematic on _____________. a. Level landscapes b. Hill landscapes c. Wet soil

IV. Analysis

Analysis for the two trials was conducted separately due to the number of procedural changes between the two semesters. However, the analysis goals for both trials were largely the same (Table 5). The data was analyzed using SPSS (SPSS Inc.,Version 16.0, 2008). Exploratory analysis showed significant non-normality in the data, so non-parametric methods were used in the analysis (Table 5). Quiz score retention was calculated by subtracting the quiz two score from the quiz one score.

Table 5. Analysis goals with corresponding semester(s) and statistical tests.

Semester(s)	Analysis Question	Test Used
Fall 2009, Spring 2010	Was there a significant difference in pre-test scores between groups?	Mann-Whitney Test
Fall 2009, Spring 2010	Was there a significant difference in quiz scores between groups?	Mann-Whitney Test
Fall 2009, Spring 2010	Was there a significant difference in quiz score retention between groups?	Mann-Whitney Test
Fall 2009, Spring 2010	Did the two quiz scores significantly differ from each other?	Wilcoxon Signed Rank Test
Fall 2009, Spring 2010	Did the pre-test scores significantly differ from the mean quiz scores?	Wilcoxon Signed Rank Test
Fall 2009, Spring 2010	Was there a significant difference in individual, quiz question scores between groups?	Mann-Whitney Test
Fall 2009, Spring 2010	Was there a significant difference in survey responses between groups?	Mann-Whitney Test
Spring 2010	Did the responses for survey two show a significant preference for either laboratory group?	Binomial Test
Fall 2009, Spring 2010	Was there a significant correlation between how well students performed on individual quiz questions, and how high the students rated their understanding of the corresponding learning objective on the survey?	Spearman Correlation

RESULTS

Trial one in the Fall 2009 semester had 77 participants, 36 participants in the Lecture Group and 41 participants in the Simulator Group. Laboratory sections were divided into the groups as shown in Table 6. The pre-test showed no significant difference between groups ($p=0.708$). The quiz one and quiz two scores showed no significant difference between groups ($p=0.108$, $p=0.393$). Mean pre-test and quiz scores are shown in Figure 6.

Quiz retention scores showed no significant difference between groups ($p=0.185$). There was a significant difference between the mean quiz scores and pre-test scores ($p<0.001$). There was a significant difference between quiz one and quiz two scores ($p=0.022$). Of the ten quiz question scores, question two on quiz one showed a significant difference between the two groups ($p<0.001$; Figure 7). Of the 16 survey questions, question one showed a significant difference between groups ($p=0.007$; Figure 8). Examples of the most frequent comments can be seen in Table 8. Quiz question performance and survey responses were significantly correlated for learning objectives six and eight with correlation coefficients of 0.296 and 0.243 respectively ($p=0.026$, $p=0.040$).

Trial two in the Spring 2010 semester had 80 participants, 41 participants in the Lecture Group and 39 participants in the Simulator Group. Laboratory sections were divided into the groups as shown in Table 1. The pre-test showed no significant difference between groups ($p=0.170$). The quiz one and quiz two scores showed no significant difference between groups ($p=0.193$, $p=0.359$). Mean pre-test and quiz scores can be seen in Figure 10. Quiz retention scores showed no significant difference between groups ($p=0.460$). There was a significant difference between the mean quiz scores and pre-test scores ($p<0.001$). There was a significant difference between quiz one and quiz two scores ($p<0.001$). Of the 20 quiz questions scores, questions two on quiz one and question eight on quiz two showed a significant difference between the two groups ($p<0.001$, $p=0.016$; Figure 10). Of the 16 survey questions on survey one, questions one, ten, and thirteen showed a significant difference between groups (Figure 11). Examples of the most frequent comments can be seen in Table 10. Of the 16 survey question responses on survey two, questions eight through thirteen, fifteen, and sixteen showed a significant preference for the Simulator Group (Figure 12). None of the question responses on survey two showed a significant preference for the Lecture Group (Figure 12). Quiz question performance and survey responses for survey one were significantly correlated for learning objectives three, seven, and eight with correlation coefficients of 0.321, 0.252 and 0.309 respectively ($p= 0.007$, $p=0.035$, $p=0.009$). Quiz question performance and survey responses for survey two were not significantly correlated.

Table 6. Laboratory sections with corresponding day, time, and assigned groups for the Fall 2009 and Spring 2010 semesters.

Semester	**Laboratory Section**	**Day and Time**	**Group**
Fall 2009	1	Monday 1:30	Simulator
	2	Tuesday 8:30	Lecture
	3	Tuesday 10:30	Simulator
	4	Tuesday 1:30	Lecture
	5	Tuesday 3:30	Lecture
	6	Thursday 10:30	Simulator
Spring 2010	1	Monday 1:30	Lecture
	2	Tuesday 8:30	Lecture
	3	Tuesday 10:30	Simulator
	4	Tuesday 1:30	Simulator
	5	Tuesday 3:30	Lecture
	6	Wednesday 1:30	Simulator
	7	Thursday 10:30	Lecture

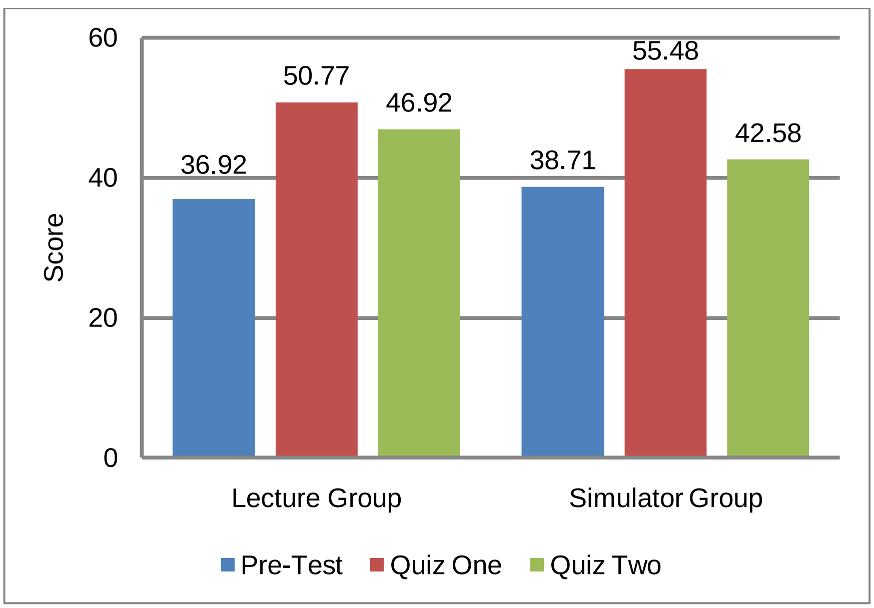

Figure 6. Fall 2009 mean pre-test, quiz one, and quiz two scores by group. There are no significant differences between groups.

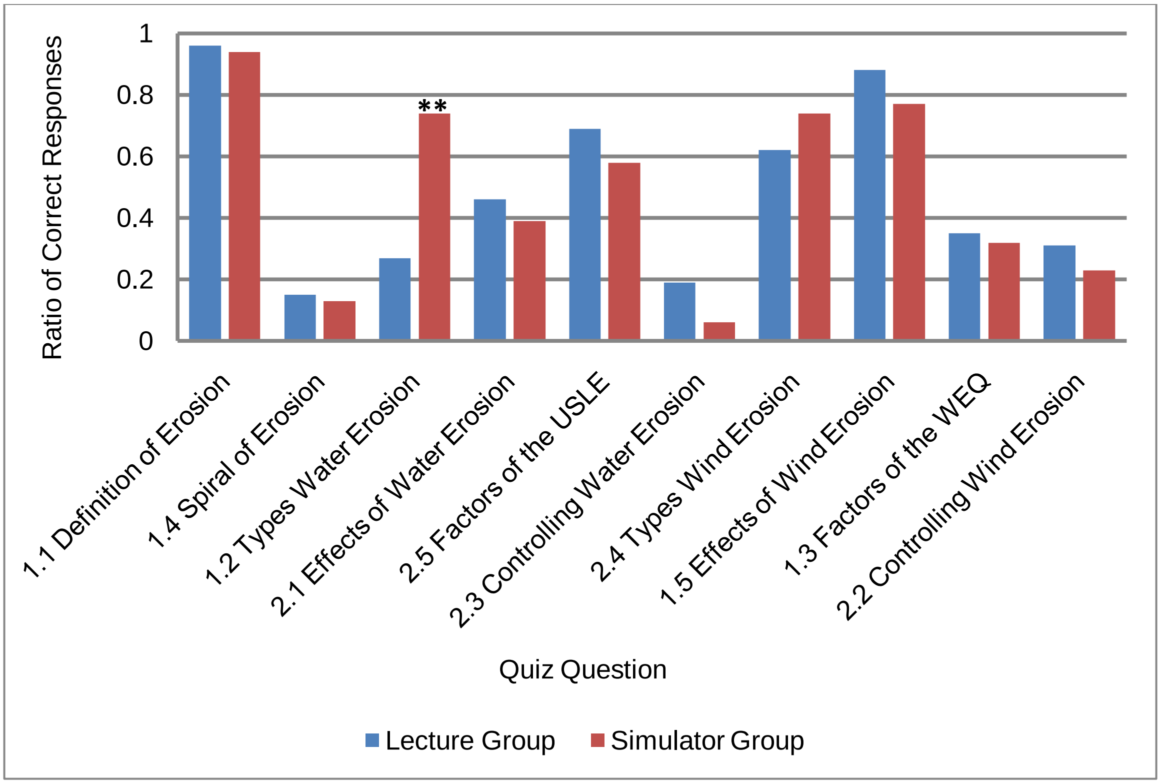

Figure 7. Fall 2009 mean ratio of correct responses to individual quiz questions. Quiz questions are labeled with corresponding learning objectives; the format is *QuizNumber.QuizQuestion_Learning Objective*.
**P-value < 0.005.

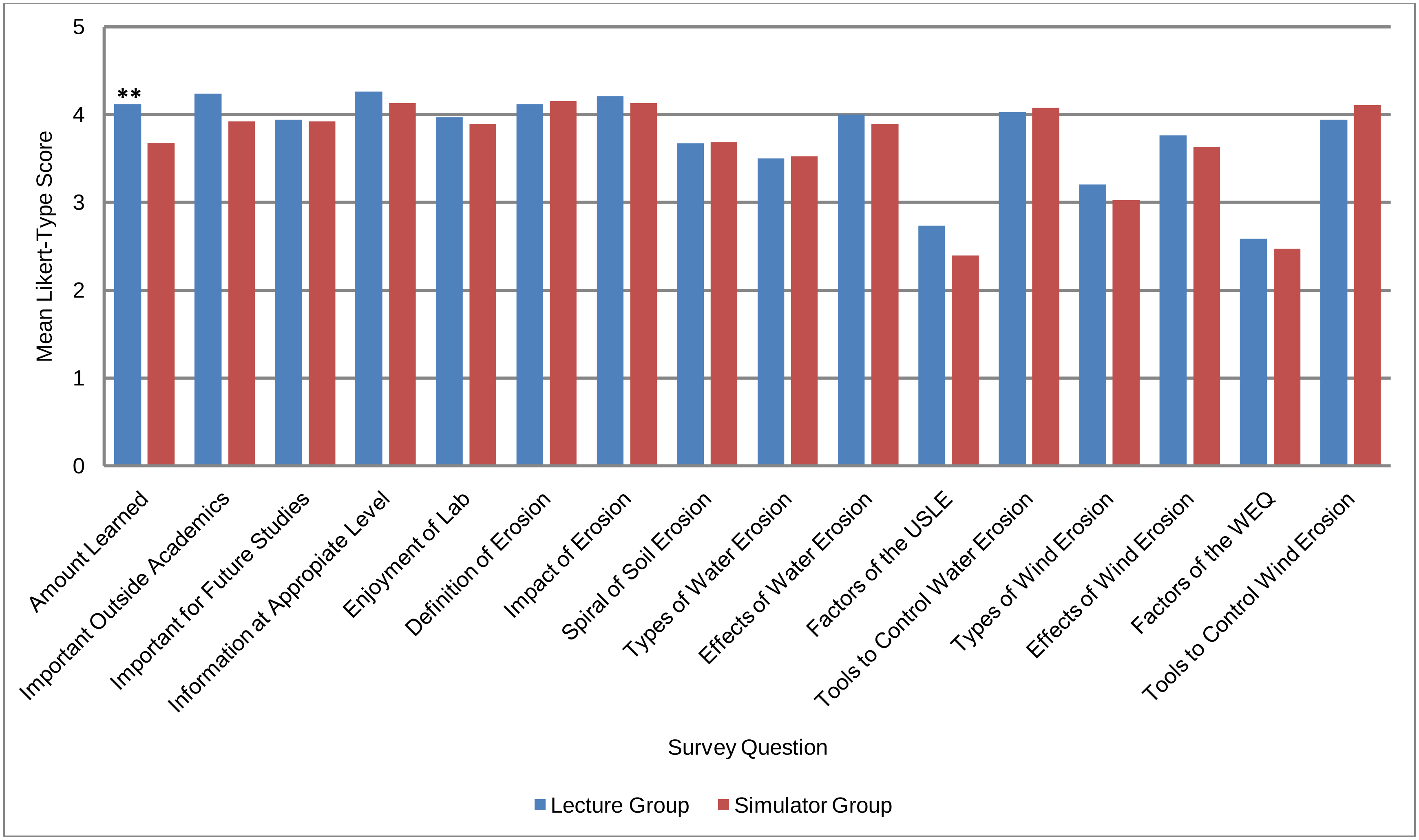

Figure 8. Fall 2009 mean survey responses on a Likert-type scale. Results are in order of the question's subject rather than question number.
*P-value < 0.05

Table 7. Examples of most frequent comments from survey one in the Fall 2009 semester.

Survey Question	Lecture Group	Simulator Group
Please write two things that you liked about the lab.	“Seeing the difference between the intensities of ‘rain’ and how different soil textures react to the different intensities” “Lots of relevant, useful information”	“Hands on activity” “Seeing the wind tunnel” “I love not being in the classroom. Field trips are always fun and interesting.” “Seeing the effects of water erosion”
Please write two things that you disliked about the lab.	“Long lecture”	“We didn’t have much time.” “Maybe should be split up into two [labs], felt like it was a lot of information to handle.” “Math, I hate math.”

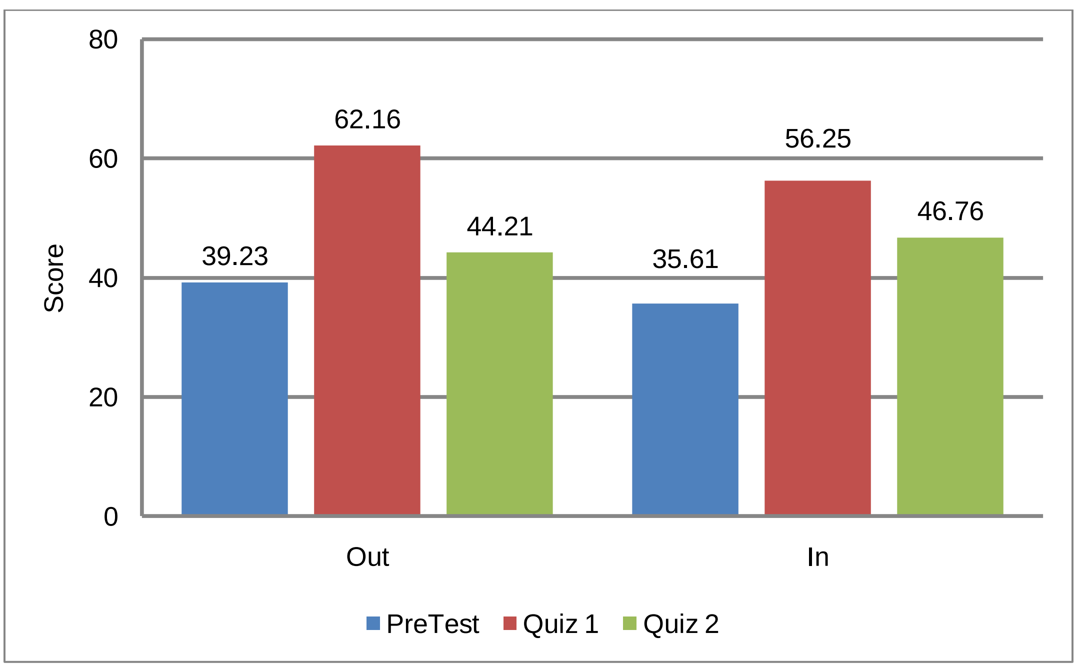

Figure 9. Spring 2010 mean pre-test, quiz one, and quiz two scores by group. There were no significant differences between groups.

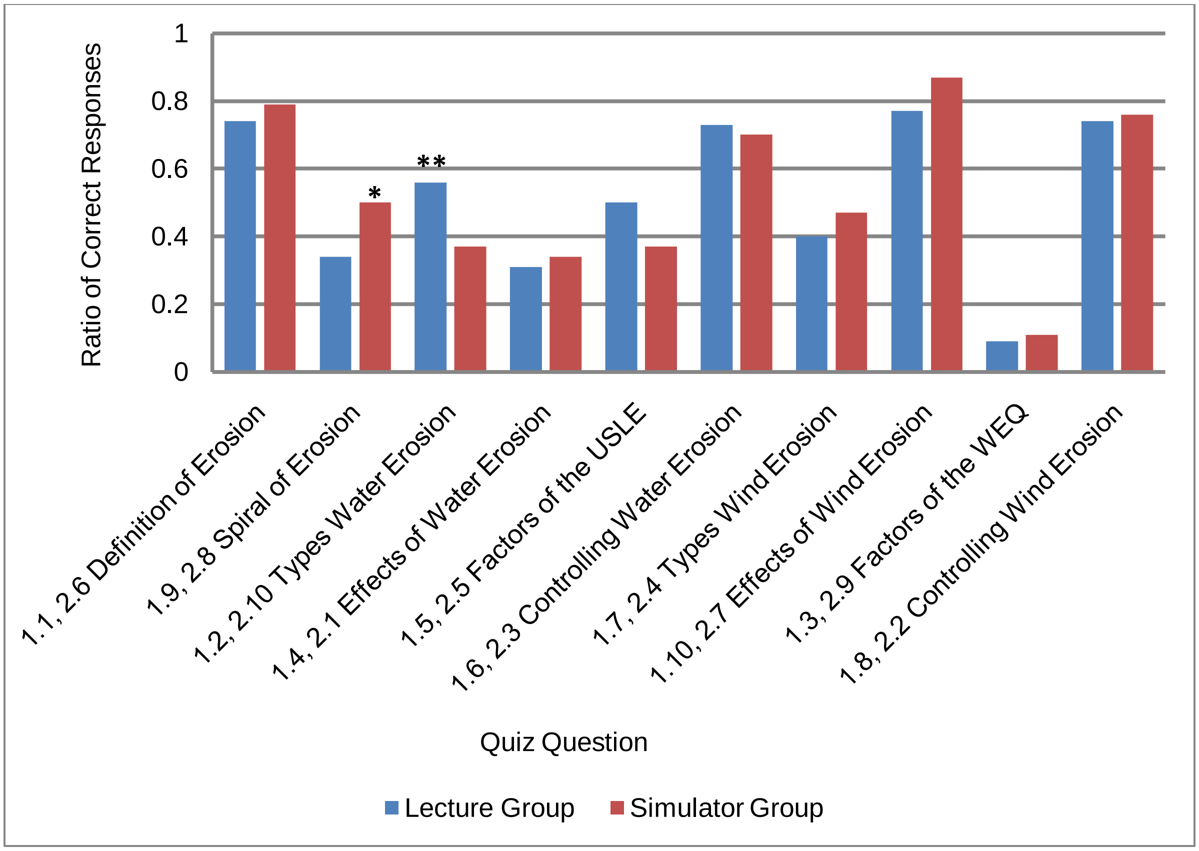

Figure 10. Spring 2010 mean ratio of correct responses to quiz questions. Each bar represents two quiz questions which have been averaged together from quizzes one and two. Quiz questions are labeled with corresponding learning objectives; the format is *Quiz1.QuizQuestion, Quiz2.QuizQuestion_Learning Objective*.
*P-value<0.05, **P-value < 0.005.

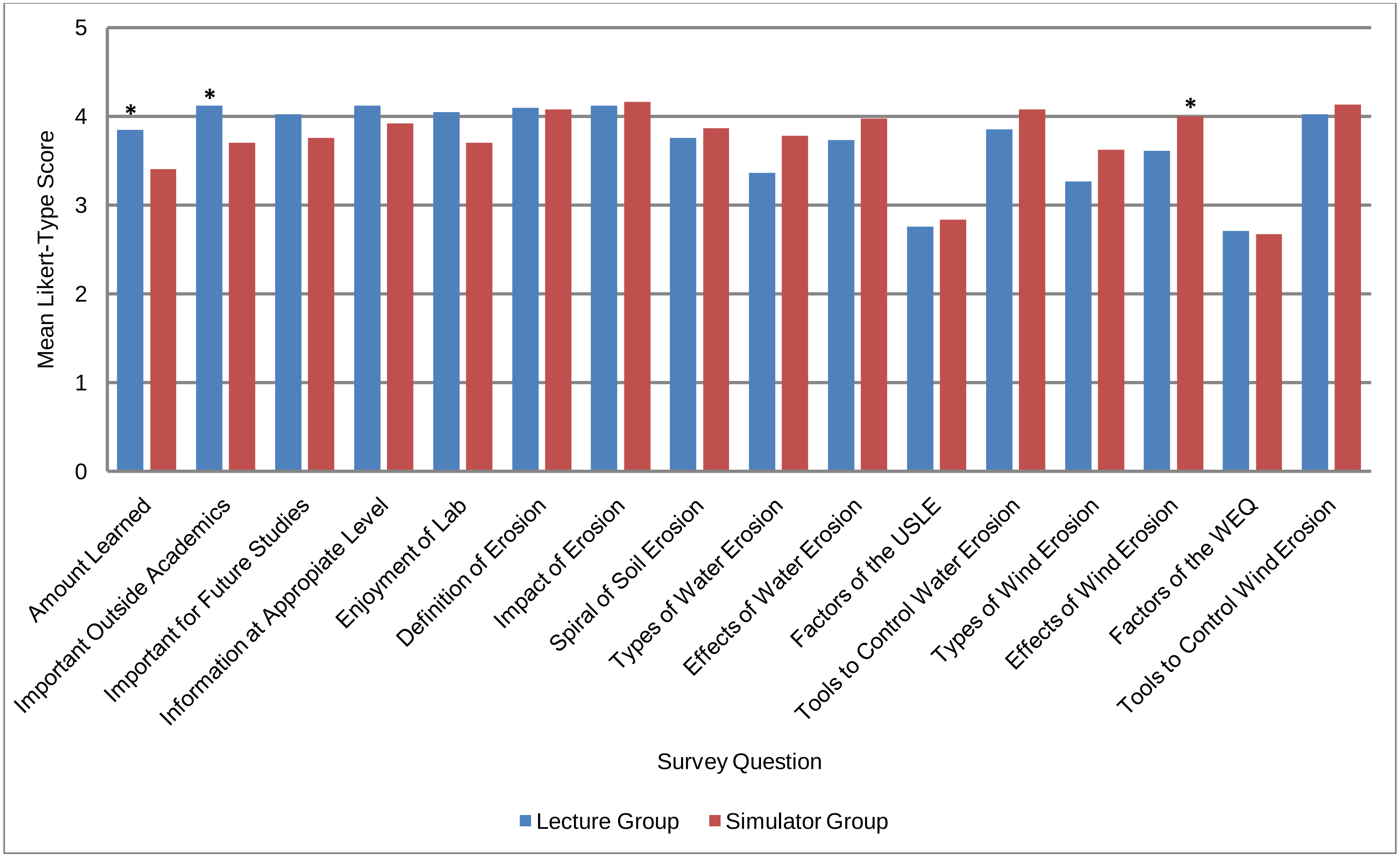

Figure 11. Spring 2010 mean survey one responses on a Likert-type scale. These results are in order of the question's subject rather than question number.

*P-value < 0.05

Table 8. Examples of most frequent comments from survey one in the Spring 2010 semester.

Survey Question	Lecture Group	Simulator Group
Please write two things that you liked about the lab.	"I got creative on the model to get various results" "I got my hands dirty" "I got to plant trees and build terraces"	"Wind tunnel is pretty cool" "All of the hands on things that we got to do and see, being in a different environment was nice" "Rainfall simulator"
Please write two things that you disliked about the lab.	"I wish we could have seen what wind does to soil" "Sometimes the effect of erosion weren't totally accurate" "There wasn't really anything I disliked"	"Equations, time." "Very time consuming. It would be fine if we had more time" "Being split up into different groups; I feel like we did not learn what the other groups did" "Being outside in the freezing cold"

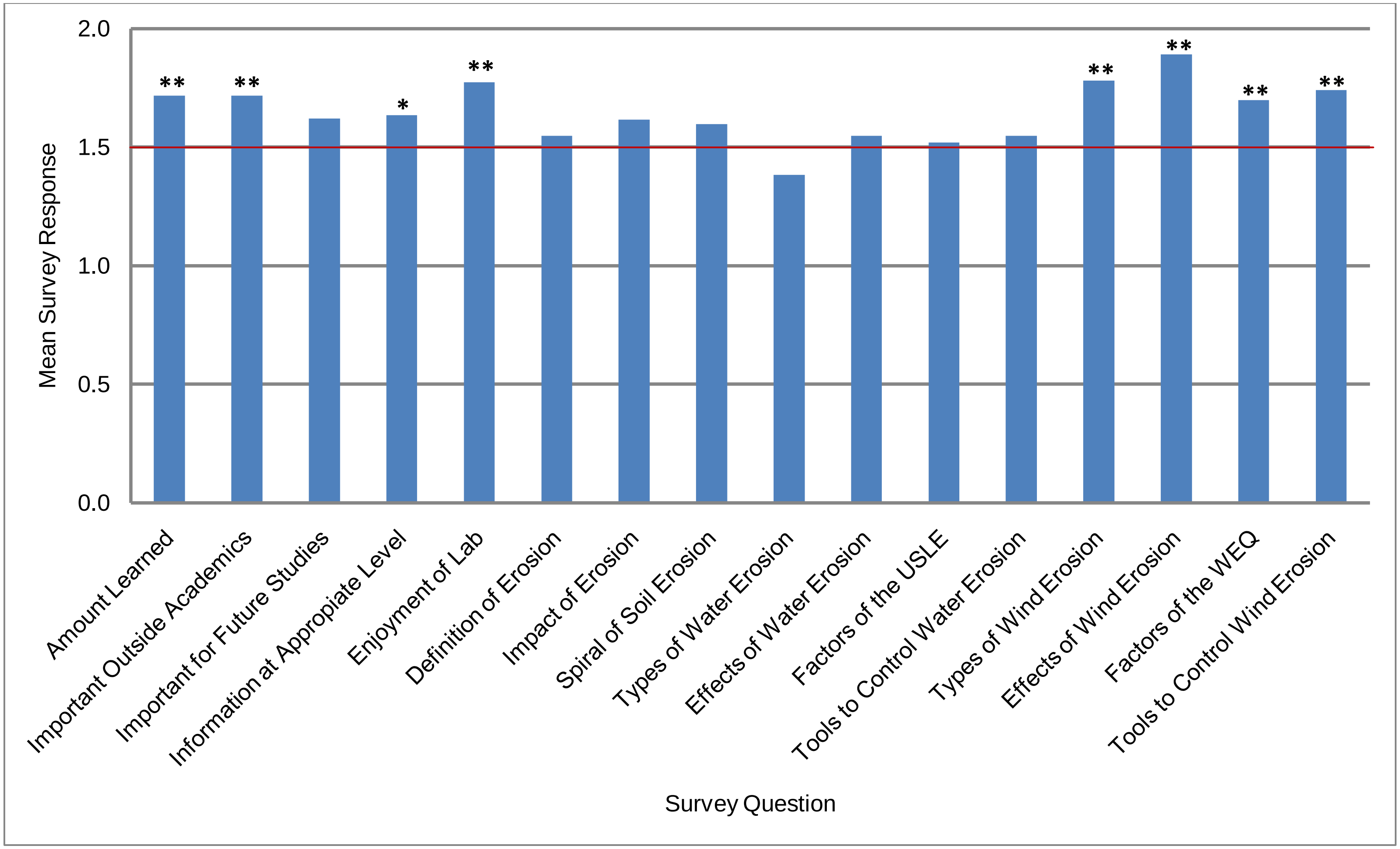

Figure 12. Spring 2010 mean survey two responses. Preference for the Lecture Group was inputted as number one, and preference for the Simulator Group was inputted as number two. Any mean above 1.5 indicates a preference for the Simulator Group. The red line indicates a mean of 1.5. These results are in order of the question's subject rather than question number.
*P-value < 0.05, **P-value < 0.005

DISCUSSION AND CONCLUSION

Discussion and Experimental Problems

As indicated by the non-significance of the pre-test scores, neither group began with an advantage in content knowledge. The mean pre-test score for both trials was only slightly above chance, which is 33.3%, suggesting that the students came in with little background knowledge pertaining to the ten learning objectives. The non-significance of quiz scores and quiz score retention between groups suggested that students in both groups understood the learning objectives equally well. Significant differences in pre-test, mean quiz scores, quiz one, and quiz two scores reflected the expected improvement in content knowledge after the completion of the laboratory and the partial loss of that knowledge during the intervening four weeks from quiz one to quiz two. Low average quiz scores were likely the result of low extrinsic motivation; the quiz grades for the soil conservation experiment did not comprise any portion of the students' final grades.

Across both trials, analysis of individual, quiz questions showed few significant differences, which was consistent with the lack of significance for overall quiz scores. The significant differences for individual, quiz questions did not emerge as a pattern across trials and were not explained by group differences. In both trials, students performed significantly more poorly on questions pertaining to the WEQ and the detrimental effects of water erosion. Most likely, poor performance on WEQ questions was heavily influenced by students' low level of familiarity with the variables of the WEQ as compared to the other learning objectives.

Across both trials, survey one had few significant differences between groups, suggesting that the large-scale simulators did not have a strong impact on student opinion. For both trials, the Lecture Group had more significantly positive responses and reported that they learned more than the Simulator Group. However, the results of survey two clearly suggested that the students formed more favorable opinions of the Simulator Group when directly compared with the Lecture Group, especially for learning objectives pertaining to wind erosion. Because the Lecture Group did not provide students with a hands-on, wind erosion experiment, it is not surprising that students indicated that the Simulator Group provided them with a better understanding of wind erosion. More positive responses produced by the Lecture Group on survey one may be the result of the lower level of mathematical difficulty associated with the Lecture Group. This could have created a "halo effect" in which the students' enjoyment of the laboratory interfered with their perception of its effectiveness (Gentry, Commuri, Burns, and Dickenson, 1998).

Across both trials, students' impressions of how well they understood the learning objectives, as described by their survey responses, were not well correlated to their performance on quiz questions pertaining to those learning objectives. This is either reflective of poorly designed quizzes which did not accurately assess student learning, or it is indicative of low student ability to assess their own learning.

The most frequent comments from survey one for both trials reflect the changes in methodology from trial one to trial two. In trial one, the Lecture Group disliked the length of the in-laboratory lecture, but it trial two, that comment was infrequent due to the shortened lecture. The Lecture Group enjoyed the hands-on aspect during both trials, but in trial two, it is evident that the students appreciated the ability to be creative during laboratory through their creation of terraces and cropping patterns. For the Simulator Group, the positive and negative comments remained similar across both trials. Students enjoyed the time away from the classroom and the use of the simulators, but they felt rushed and disliked the emphasis on math. The outdoor environment generated some negative feedback during trial two because the weather was unfavorable.

Additional Experimental Problems

There were multiple confounding variables in this experiment. Laboratory sections took place at different times of the day on different days of the week; this introduced multiple unintentional environmental and student personality variables (Gentry, Commuri, Burns, and Dickenson, 1998). As the instructor taught the laboratory sections, instructive performance improved through practice and familiarity with student responses so that laboratory sections later in the week received a more polished presentation. This effect was more limited during the second trial. During both trials, some of the laboratory sections were taught by the instructor throughout the semester, and some were not. Thus, students in laboratory sections who were already familiar with the instructor might have understood the content better due to their familiarity with the instructor's mode of presentation.

Quiz questions did not have consistent formatting. Eighty percent of the questions were multiple-choice, and 20 percent were short answer. This could have significantly altered the difficulty of the questions. However, the lowest scoring questions during both semesters were a mixture of multiple-choice and short answer questions. In the first trial, the quizzes did not have all ten learning objectives on each quiz, which meant that performance across learning objectives was not reliably comparable; this was rectified during the second trial.

Conclusion

The results of this experiment are similar to the findings of Mamo and Kettler (2004) who found that the two methods of teaching soil conservation did not produce significantly different quiz scores, but the computer simulation was favored over the worksheet. As with Mamo and Kettler (2004) neither group produced significantly different quiz scores, but the Simulator Group was clearly favored by the students when compared with the Lecture Group.

The methods of this experiment offer educators two ways of utilizing hands-on experiments for teaching soil conservation. The Simulator Group methodology is effective and more appropriate for college level students, but it requires funds and access to equipment. Methods for the Lecture Group offer a less expensive activity that produced equal gains in content knowledge. However, for future classroom use, it would be appropriate to add a wind erosion experiment to the Lecture Group.

The ultimate goal of soil conservation education is to equip students with an awareness of soil conservation issues and the ability to understand and make positive contributions to the reduction of soil erosion. For non-agricultural students, this can mean participation in service projects that reduce erosion, identification and control of erosion at home, and daily sensitivity to their impacts on the ecosystem. Agricultural students have the potential to create significant impacts in erosion reduction through the implementation of conservation tillage and additional support practices. Thus, future studies in soil conservation should also include pre and post surveys that assess the current soil conservation practices of the students, and efforts should be made to give students experience with working with up-to-date models that predict water and wind erosion.

CHAPTER II

INTRODUCTION

Bloom's Taxonomy: Introduction

The Taxonomy of Educational Objectives, also known as Bloom's Taxonomy, was formally introduced in the 1956 handbook, *Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook I: Cognitive Domain*. Six taxonomic categories were developed with up to 12 subcategories per category (Appendix V). This system of categories and subcategories provides generality at the category level and optional specificity at the subcategory level to prevent complex educational objectives from being forcefully fragmented in to narrow classifications. Bloom's Taxonomy was intended to facilitate conversation between educators by providing a common language of educational objectives. It was also designed to assist educators in defining their curricular goals; this would allow educators to "gain a perspective" on the cognitive domain on which their curriculum placed emphasis. The text also offers examples of multiple choice questions associated with each level of the cognitive domain. It makes no value judgments as to the merits of the levels of the cognitive domain. Levels are ordered into a cumulative hierarchal structure from simple to complex processes. The cumulative structure indicates that, in order to reach the level of *analysis*, students must be competent in *knowledge*, *comprehension*, and *application* levels (Bloom et al., 1956).

Bloom's Taxonomy: Criticisms

In 1981, one of the authors of the *Taxonomy of Educational Objectives*, conducted a meta-analysis of the criticisms of Bloom's taxonomy. The taxonomy was first criticized for limiting its classifications to categories that could be described by student behaviors. By only considering goals from educational philosophies that could be classified by student behaviors, the authors did not remain neutral with respect to those educational philosophies. Furthermore, these behavioral classifications were criticized as being unobservable processes that authors of the taxonomy could not accurately measure. Thus, authors of the taxonomy relied on the assumption that correct responses to test items provided sufficient evidence for the cognitive processes of the taxonomy (Furst, 1981). Students given a mathematical exam that tested knowledge, comprehension, and application levels of Bloom's Taxonomy were asked to think aloud while taking the exam and then explain how they arrived at their answer once they had selected a response. Cognitive processes used by the students matched the Bloom's Taxonomy cognitive category 54% of the time (Gierl, 1997).

Categories were also criticized for not including content area as part of the taxonomy. Critics posited that a student could not simply remember, they must remember *something*; that something is the content area. Thus, to separate cognitive process from content area created an overly artificial classification. Furst responded by commenting that authors of the taxonomy sacrificed the precision of including content area in order to make a taxonomy that generalized across all subjects. Multiple sources reported that the comprehensiveness of the taxonomy was insufficient for classifying oral questions as well as for classifying educational objectives that included the affective and psychomotor domains such as development of sensitivity (Apt, 1971; Gall, 1970; Hirst, 1974; Kamii, 1971; Klopfer, 1971; Mills et al., 1980; Orlandi, 1971; Ormell, 1974; Raths et al., 1967; Riegle, 1976; Wilhoyte, 1965). The hierarchal structure of the taxonomy was inconsistent with respect to difficulty, causing inversions and overlaps between levels (Furst, 1981). Specifically criticized was the placement of *evaluation* after *synthesis*, stating that it is easier to criticize than to create (Ormell, 1974).

Predominant criticisms of Bloom's Taxonomy call for a broader taxonomy which would better incorporate categories from multiple educational philosophies, which lacked the limiting hierarchal structure of the original taxonomy, and which could more comprehensively cover multiple content areas. Conversely, some critics of the taxonomy call for greater specificity to relate directly to content areas and provide better evidence of cognitive processes.

Original Bloom's Taxonomy: Application

Despite these criticisms, Bloom's taxonomy has been used "by curriculum planners, administrators, researchers, and classroom teachers at all levels of education." It has been translated into eighteen languages, and cited by over 150 books and articles. The taxonomy has drawn attention to the importance of diversifying the classroom experience from memorized knowledge to more complex, cognitive processes. It is a widely known and generally accepted tool for the analysis of curriculum goals, classroom assessment, course materials, and standardized exams (Anderson and Sosniak, 1994).

Revised Bloom's Taxonomy: Introduction

In 2001, a revision of Bloom's Taxonomy was published with the goal of refocusing educators on the value of an educational taxonomy and incorporating new knowledge and philosophy from educational and psychological literature into the taxonomic system. Changes to the taxonomy included shifted emphases, altered structure, and new terminology. The authors created a greater emphasis on curriculum planning to accompany the emphasis on assessment in the original Bloom's Taxonomy. Where the original taxonomy primarily contained examples of multiple-choice questions, the Revised Bloom's Taxonomy contained an increased number of examples pertaining to classroom learning objectives. These examples of classroom learning objectives made the revised taxonomy more applicable to primary and secondary educators (Anderson et al., 2001).

The Revised Taxonomy incorporated structural changes by creating a knowledge dimension based on the subcategories of the knowledge classification from the original taxonomy. Addition of a separate, knowledge dimension gave rise to a two dimensional taxonomy table. The *metacognitive* knowledge classification represents a classification not found in the original taxonomy that was added to increase the comprehensiveness of the taxonomy. Metacognitive knowledge refers to a student's knowledge of his/her cognitive process or the cognitive processes necessary for problem solving. Lastly, the hierarchal structure was maintained but not as a cumulative hierarchy. In other words, mastery of the *apply* cognitive domain does not require mastery of the *remember* and *understand* domains (Anderson et al., 2001).

The revised taxonomy incorporated multiple changes in terminology. Names of the cognitive domain categories changed from noun to verb form and created consistency with the way objectives were originally framed (Anderson et al., 2001). As previously described, levels of Bloom's Taxonomy were derived from categories that could be described by student behavior (Bloom et al., 1956). The change from noun to verb form also permitted combined use of the cognitive domain and knowledge dimension as a verb-noun coupling. For instance, a student can *remember procedural knowledge*. Classifications *create* and *evaluate* switched numerical because creation requires evaluation of parts in order to assemble something new. Two cognitive categories changed names rather than simply undergoing the noun to verb form change; c*omprehension* became *understand* and *synthesis* became *create*. Category *understand* was added due to the fact that it is a term that is frequently used by educators (Anderson et al., 2001).

Table 9. Revised Bloom's Taxonomy Table

	Cognitive Domain					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
Knowledge Dimension						
A. Factual						
B. Conceptual						
C. Procedural						
D. Metacognitive						

Revised Bloom's Taxonomy: Application and Criticisms

Intended uses of the Revised Bloom's Taxonomy are similar in scope to the original Bloom's Taxonomy which are to focus on curriculum development from a single assignment to whole course design. The Revised Bloom's Taxonomy helps teachers align their curriculum with the standards of the school, district, or state without being forced to "teach to the test" (Airasian and Miranda, 2002). At the university level, Betts (2008) used the revised taxonomy to design curriculum intended to reach high levels of the cognitive domain while compensating for the varied background of graduate students. Bumen (2007) compared lesson plans of students who designed their curriculum using the original taxonomy versus students who used the revised taxonomy. Students who used the revised taxonomy scored significantly higher on their lesson plans in alignment/consistency, duration, assessment, and closure.

The Revised Bloom's Taxonomy has also been integrated with other taxonomies for curriculum development and assessment. For instance, Noble (2004) integrated the revised taxonomy with Gardner's theory of multiple intelligences to create a new, two-dimensional table which allowed educators to select both a cognitive level and an intelligence type when designing curriculum.

Nasstrom (2009) tested the interpretive ability of the Revised Bloom's Taxonomy by having two panels of judges separately categorize a syllabus according to the Revised Bloom's Taxonomy. High levels of consistency between the panel's classifications determined the taxonomy to be a "useful tool for the interpretation of standards." The reliability of the taxonomy as an interpretive tool permits researchers to use it as a tool of standardization. For instance, Parham et al. (2009) used the revised taxonomy to code transcripts of students verbally solving problems in order to determine what makes students better problem solvers, and Hanna (2007) modified the Revised Bloom's Taxonomy to standardize the goals of music education.

Bloom's Taxonomy: Use in Question Classification

To date, the Revised Bloom's Taxonomy has not been used to classify either multiple choice or short answer questions. Review of the use of the original taxonomy indicates it has been used to classify questions from standardized exams, course exams, textbooks, and laboratory manuals; classifications provided a basis for the improvement of curriculum and selection of cognitively challenging course materials (Clevenstine, 1987; Davila and Talanquer, 2010; Domin, 1999; Fuller, 1997; Hampton and And, 1993; McCormick and Whittington, 2000; Oliver and Dobele, 2007; Pfeffier and Davis, 1965; Risner et al., 2000; Takona, 1999). The majority of authors chose to classify the questions within the six categories of the taxonomy (Clevenstine, 1987; Davila and Talanquer, 2010; Domin, 1999; McCormick and Whittington, 2000; Oliver and Dobele, 2007; Risner et al., 2000; Takona, 1999). Some authors simplified the process by giving the upper levels of Bloom's taxonomy one designation and the lower levels another (Fuller, 1997; Hampton and And, 1993). For instance, Hampton and And (1993) divided the taxonomy into two levels, the *knowledge* level and the *intellectual ability and skill* level. Very few authors chose the specificity of the subcategory level (Pfeffier and Davis, 1965).

Researchers took different approaches to the standardization of the taxonomy between judges with most providing training sessions (Fuller, 1997; Hampton and And, 1993; Oliver and Dobele, 2007; Risner et al., 2000; Takona, 1999). However, Clevenstine (1987) used experienced judges to eliminate the need for training. Illustrative verb lists were given to judges to assist with cognitive category selection (Domin, 1999; McCormick and Whittington, 2000). Davila and Talanquer (2010) calibrated the judges perceptions through initial classification of random questions. Results were frequently reported as percentages without additional statistical analysis (Fuller, 1997; McCormick and Whittington, 2000; Oliver and Dobele, 2007; Pfeffier and Davis, 1965). Alternatively, some authors chose to use a chi-squared test (Clevenstine, 1987; Davila and Talanquer, 2010; Hampton and And, 1993; Risner et al.,2000 ; Takona, 1999). Domin (1999) reported his results by simply denoting the presence or absence of cognitive levels within laboratory manuals.

A study by Clements and Rothenberg (1996), using the original Bloom's Taxonomy, found that test length decreased as the taxonomic levels of the exams increased. This decreased test length led to the criticism that that increasing levels of test complexity can lead to decreasing test reliability because that shorter tests are statistically less reliable (Clements and Rothenberg, 1996).

Revised Bloom's Taxonomy: Experimental Goals

SOIL2124, Introductory Soil Science, is an undergraduate level course with approximately 105 students per semester. The class contains students from multiple majors including Agricultural Education, Agricultural Engineering, Biosystems and Civil Engineering, Environmental Science, Horticulture, Landscape Architecture, and Plant and Soil Science. The Revised Bloom's Taxonomy was chosen to classify exams for SOIL2124 because it provides a simple interface for classification and it permits analysis of both the knowledge dimension and cognitive domain. The goal of this experiment is to determine if there is a difference between SOIL2124 exams in taxonomic level for the Revised Bloom's Taxonomy classification, the cognitive domain classification, or the knowledge dimension classification. Independent variables for this experiment are Exam Year, Exam Total, Exam Number, and Semester. Exam Total refers to the total number of exams in a semester. Some semesters had a total of three exams while others had a total of five or eight exams. Exam Number refers to the individual exam number within a semester. For instance, a semester with a total of five exams would have Exam Numbers one, two, three, four, and five. Differences are expected across Exam Year due to the instructor's development in writing style and awareness of cognitive difficulty over time. Differences are also expected across Exam Total and Exam Number due to the inherent difficulty in balancing the cognitive domain over a broad spectrum of course material. Differences are not expected across Semester because the course should change very little between semesters.

MATERIALS AND METHODS

Exams from SOIL2124, formerly AGRON2124, were supplied by the instructor. Exam questions were classified into the Cognitive Domain and Knowledge Dimension which, in combination, create the Revised Bloom's Taxonomy classifications (Krathwohl, 2002). To help maintain consistency, guidelines were created for the classification of questions into the Cognitive Domain and Knowledge Dimension (Table 12). Guidelines were generated by modifying the tables of the Knowledge Dimension and Cognitive Domain from *A Revision of Bloom's Taxonomy: An Overview* into guidelines which were directly applicable to the exams (Krathwohl, 2002). Question classifications only required nine of the possible 24 Revised Bloom's Taxonomy classifications; examples of all Revised Bloom's Taxonomy classifications used during the experiment can be seen in Table 13. Point values, the number of points assigned to a question on a specific exam, for each classified question were recorded. Exams were classified by Exam Total and Exam Number. Exam Total refers to the total number of exams in a semester, and Exam Number refers to the individual exam number within a semester. Separation of Exam Total and Exam Number was done to assess whether Exam Totals significantly differed in their classifications and if, within Exam Total, the exams had balanced classifications across Exam Number. Semester and Exam Year were also recorded. Therefore, each question was associated with a point value, Exam Total, Exam Number, Semester, Exam Year, Cognitive Domain, Knowledge Dimension, and Revised Bloom's Taxonomy classification.

Analysis was done using non-parametric statistics due to the non-normality of the data. Since exams had varying point values and numbers of questions, point values and number of questions were weighted on the percentage of the total points and questions possible. The percentage of points possible and questions possible are termed Weighted Points and Weighted Questions respectively. For example, if an 18 question exam worth 50 points had 17 points and three questions devoted to classification Analyze, then it would have 34 Weighted Points and 16.7 Weighted Questions devoted to classification Analyze. Weighted Points and Weighted Questions were analyzed as a function of Exam Year, Exam Total, and Semester using the Spearman correlation, Kruskal-Wallis test, and Mann Whitney test respectively. Exams were then separated by Exam Total. Within Exam Total, the Weighted Points and Weighted Questions were analyzed by Exam Number using the Kruskal-Wallis test. Weighted Points and Weighted Questions were analyzed within the categories of the Cognitive Domain, Knowledge Dimension, and Revised Bloom's Taxonomy classifications. For a graphical representation of the analysis, see Figure 13.

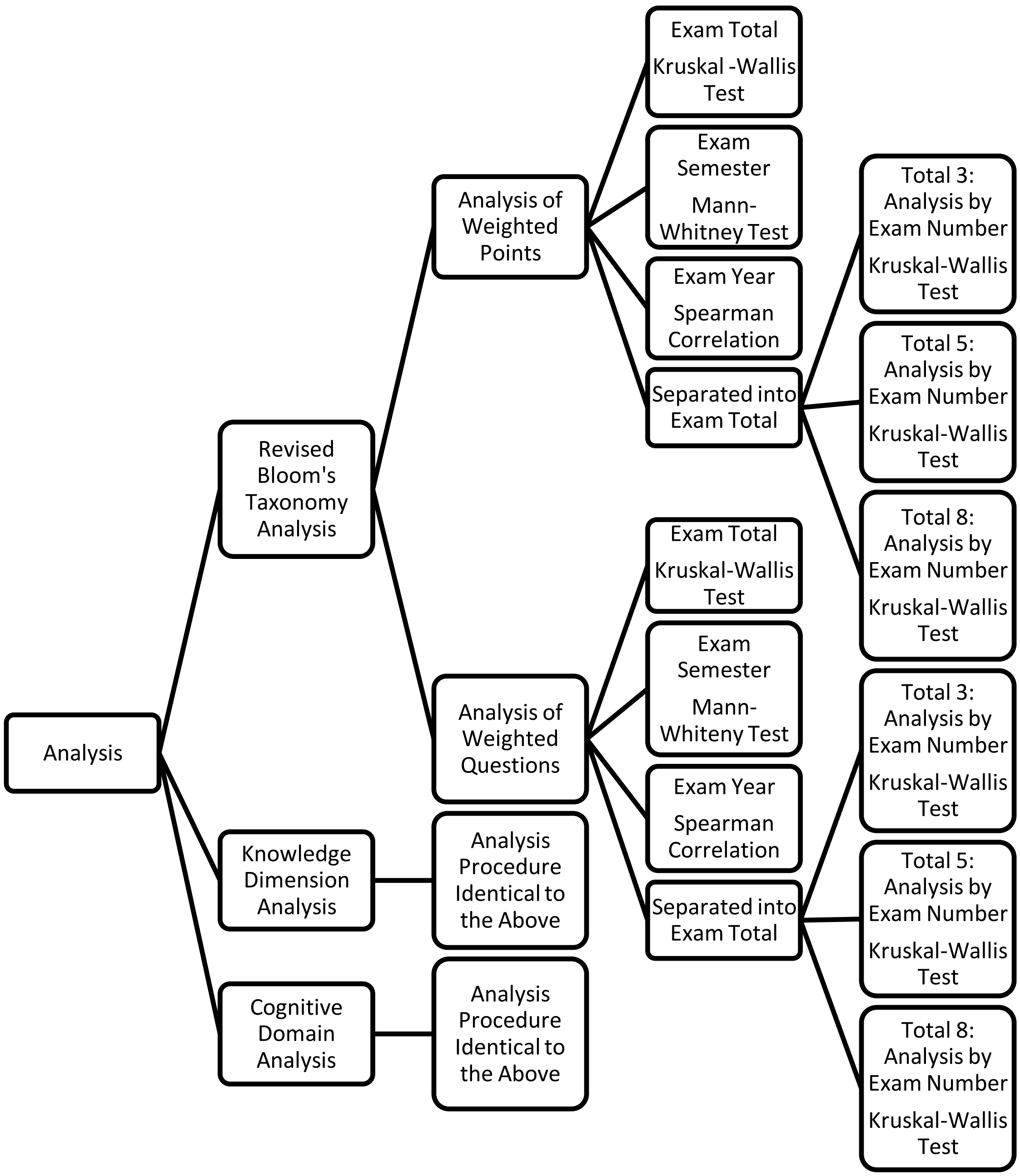

Figure 13. Flowchart for analysis of the Cognitive Domain, Knowledge Dimension, and Revised Bloom's Taxonomy classifications.

Table 10. Guidelines for classification of questions into the Cognitive Domain and Knowledge Dimension.

Bloom's Taxonomy	Guidelines
Remember	To answer the question, the student needs to recall information printed in the notes.
Understand	To answer the question, the student must make an inference based on knowledge from the notes.
Apply	To answer the question, the student must use a mathematical procedure, use a written procedure, or make a determination for a hypothetical, real world question.
Analyze	To answer the question, the student must select the pertinent information from a body of information and use it correctly within the problem.
Evaluate	To answer the question, the student must select the pertinent information from a body of information and use it to make a recommendation.
Create	To answer the question, the student must create a new product or point of view.
Knowledge Dimension	
Factual	Knowledge is derived from the definition of the subject of the question.
Conceptual	Knowledge is derived from understanding the relationships between the subject of the question and another subject or subjects.
Procedural	Knowledge is derived from mathematical or written procedures.
Metacognitive	Knowledge is derived from the student's awareness of his/her own cognitive process.

Table 11. Examples of Revised Bloom's Taxonomy classifications generated during this experiment.

Classification	Question
Remember, Factual	An A horizon is recognized as a(n) ____________. *Mineral horizon enriched with organic matter
Remember, Conceptual	Which soil texture is considered to have the most optimum characteristics for biological growth? *Loam
Remember, Procedural	What are the five steps required to determine how much amendment to add to a soil? *Required, Soil Supply, Nutrient Recommendation, Amendment Recommendation, Cost
Understand, Conceptual	The texture of the A horizon is silt loam and the Btg1 is a silt clay loam _____. *Which is an indication of minerals dissolving in the A horizon and forming secondary clay minerals in the B horizon
Apply, Conceptual	If you were making a vase in art class that you wanted to use to put your prize winning floral arrangements in, which type of clay would you choose? *Kaolinite
Apply, Procedural	What is the pH of a soil that has a hydrogen ion concentration of 6.88 $x10^{-6}$ mol L^{-1}? *5.16
Analyze, Factual	The origin of the Carwile parent material is____________ deposits. *stream and wind The profile description used to answer this question is in Appendix VI.
Analyze, Conceptual	The parent material for the Frenchtown soil series was transported by _____. *Ice The profile description used to answer this question is in Appendix VII.
Analyze, Procedural	A consulting engineer is responsible for construction of the new multimodal transportation facility at OSU was responsible for developing the plans of the new construction. The design specifies that the soil density under the parking lot must be 1.94 g/cm^3 and under the landscape area should be 1.37 g/cm^3 when they are completed. She sends her technicians to collect soil samples so they can determine what the current density for the parking and landscape areas of the soil. The samples were collected from a soil core with a diameter of 2.5-in. to a depth of 16 in. The core for the parking area was weighed wet, then dried and reweighed for weights of 2,157 and 1,748 g for the wet and dry weights respectively. For the landscaped area, the sampled with a soil core of 6 cm diameter to a depth of 20 cm the wet weight is 954 g and the dry weight is 780 g. If fill for the parking lots is needed river sand is available (2.61 g/cm^3) from a nearby supplier. This sand contains 21.5% water by weight and cost $5.75/ton. What is the bulk density of the landscape region of the soil and is it at the proper density? *1.38 g/cm3
Null	You will be doing which of the following for spring break? *Answer any of the multiple choice responses

RESULTS

Seventy-six exams from 20 semesters with a total of 1,983 questions were classified. Exam Year ranged from 1995 to 2009. There were 45 Exam Total three, 15 Exam Total five, and 16 Exam Total eight. Only semesters from which a complete set of exams could be obtained were used in the study. The results are separated into those for Revised Bloom's Taxonomy, Cognitive Domain, and Knowledge Dimension classifications with sub-sections for Weighted Points and Weighted Questions. Figures and tables presented in the Weighted Points subsection are not repeated in the Weighted Questions subsection when the statistically significant classifications are identical.

Revised Bloom's Taxonomy Classification Results

Weighted Points

Weighted Points for Revised Bloom's Taxonomy classifications did not significantly differ between Exam Totals or Exam Semesters. Classification Analyze-Conceptual was significantly correlated with Exam Year with a correlation coefficient of 0.337 ($p=0.003$; Figure 14). Exam Totals three and five showed significant differences in classifications based on Exam Number (Table 14, Figure 15). Exam Total five is not graphically represented due to the fact that significantly different classifications only appear on one of the five exams. Exam Total eight did not show any significant differences based on Exam Number. Descriptive statistics for Weighted Points for all Revised Bloom's Taxonomy classifications across all Exam Totals, Semesters, and Years are listed in Table 15.

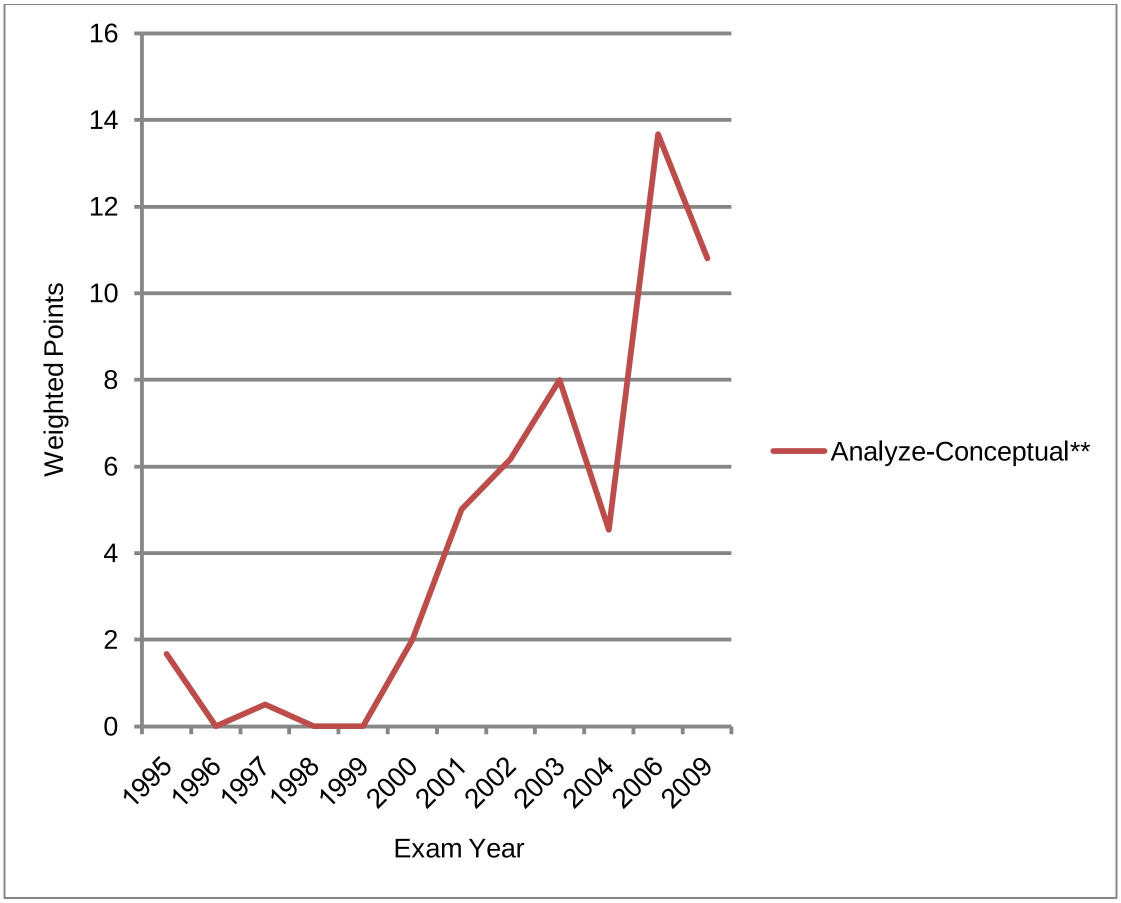

Figure 14. Mean Weighted Points assigned to the Revised Bloom's Taxonomy classification, Analyze-Conceptual, across Exam Year.
**P-value < 0.005.

Table 12. Significant Weighted Point differences in Revised Bloom's Taxonomy classifications between Exam Numbers by Exam Total.

Exam Total	Classification	P-value
3	Remember-Factual	< 0.001
3	Remember-Conceptual	0.035
3	Remember-Procedural	< 0.001
3	Apply-Procedural	< 0.001
3	Analyze-Procedural	< 0.001
5	Remember-Procedural	0.008
5	Apply-Conceptual	0.008

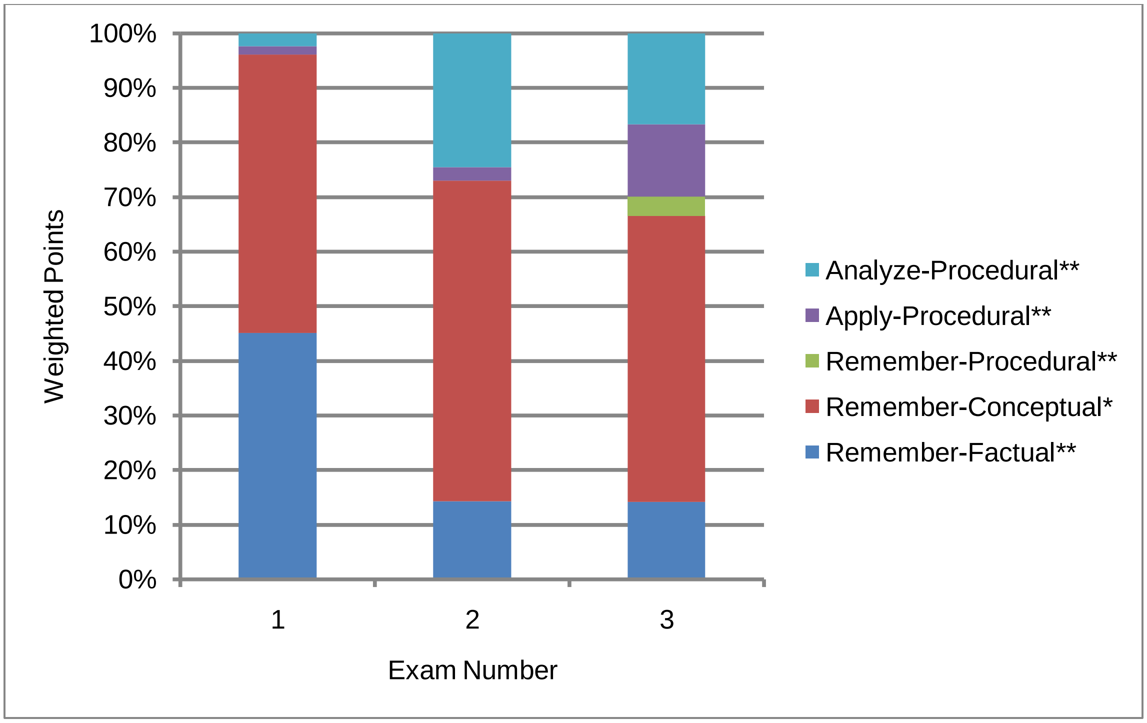

Figure 15. Mean Weighted Points for Revised Bloom's Taxonomy classifications that are significantly different between Exam Number for Exam Total three.
*P-value < 0.05,
**P-value < 0.005.

Table 13. Descriptive statistics for Weighted Points for all Revised Bloom's Taxonomy classifications across all Exam Totals, Semesters, and Years.

Classification	Mean	Standard Deviation
Remember-Factual	15.1	12.4
Remember-Conceptual	35.1	11.3
Remember-Procedural	1.1	2.7
Understand-Conceptual	26.9	11.6
Apply-Conceptual	2.0	3.5
Apply-Procedural	3.0	5.4
Analyze-Factual	0.6	3.3
Analyze-Conceptual	4.3	8.8
Analyze-Procedural	12.0	12.7
Null	0.2	0.8

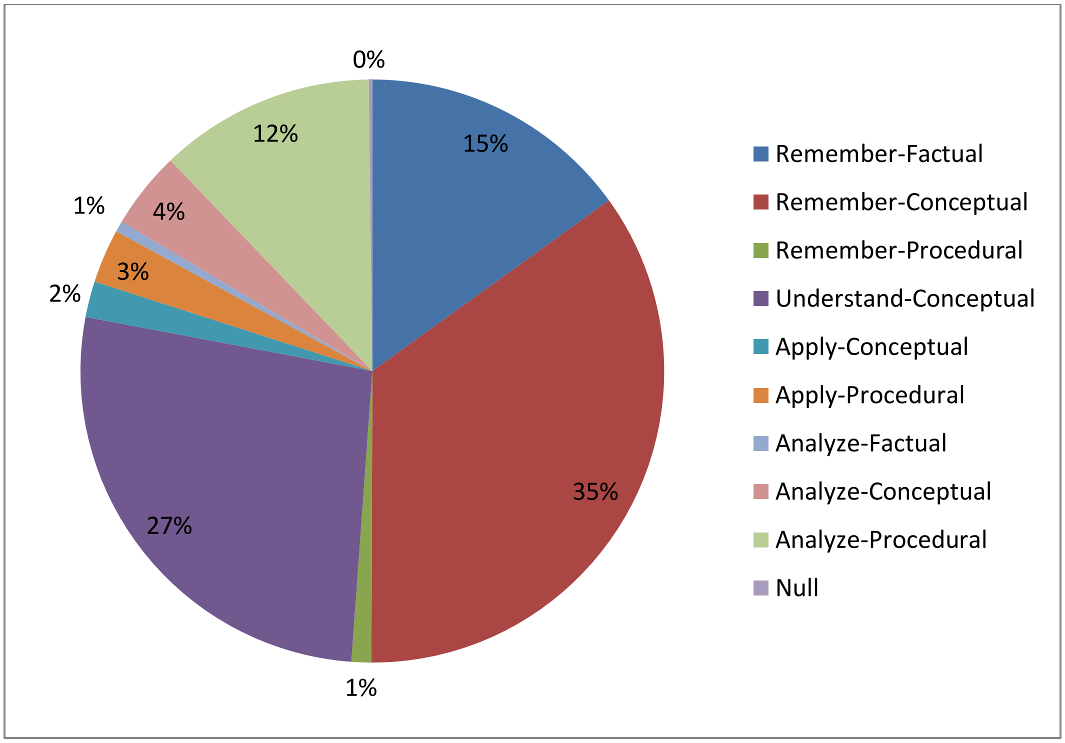

Figure 16. Mean Weighted Points for all Revised Bloom's Taxonomy classifications across all Exam Totals, Semesters, and Years.

Revised Blooms Taxonomy Classification Results

Weighted Questions

Weighted Questions for Revised Blooms Taxonomy classifications did not significantly differ between Exam Total or Exam Semester. Classification Analyze-Conceptual was significantly correlated with Exam Year with a correlation coefficient of 0.320 (p=0.005). Exam Totals three and five showed significant differences in classifications based on Exam Number (Table 16, Figure 16). Exam Total eight did not show any significant differences based on Exam Number. Descriptive statistics for Weighted Questions for all of the Revised Bloom's Taxonomy classifications across all Exam Totals, Semesters, and Years can be seen in Table 17.

Table 14. Significant Weighted Questions differences in Revised Bloom's Taxonomy classifications based on Exam Number by Exam Total.

Exam Total	Classification	P-value
3	Remember-Factual	< 0.001
3	Remember-Conceptual	0.011
3	Remember-Procedural	< 0.001
3	Understand-Conceptual	0.048
3	Apply-Procedural	< 0.001
3	Analyze-Conceptual	0.025
3	Analyze-Procedural	< 0.001
5	Remember-Procedural	0.008
5	Apply-Conceptual	0.008

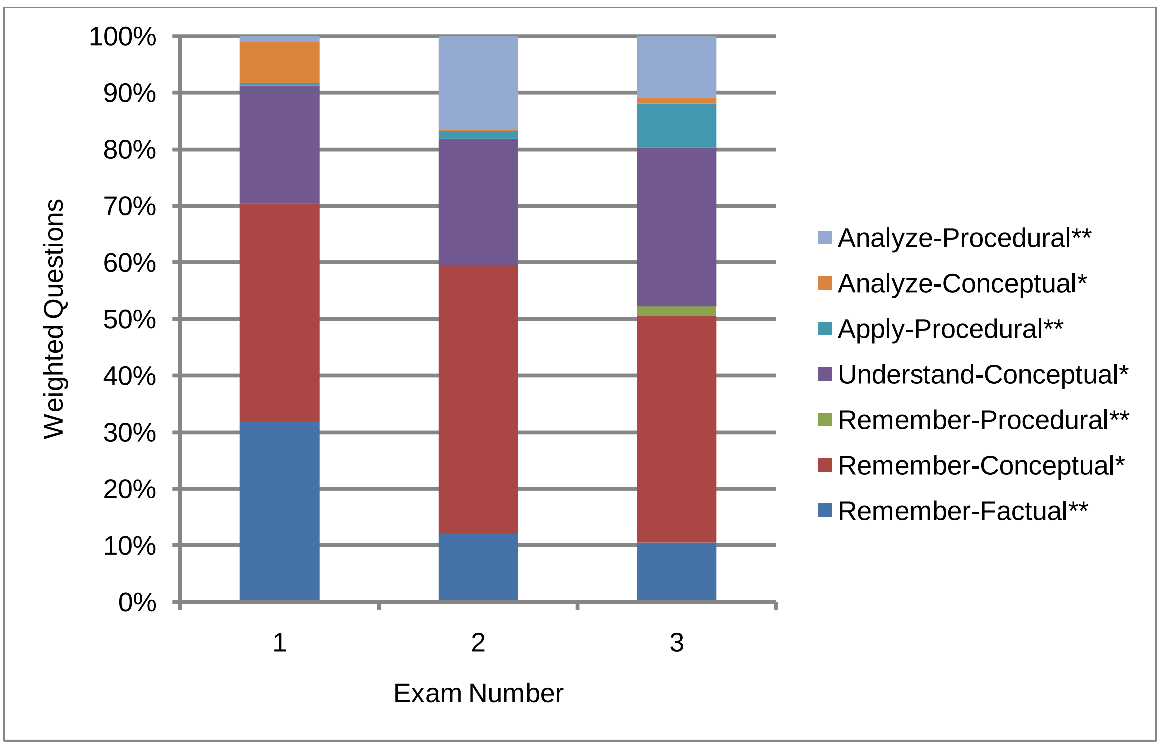

Figure 17. Mean Weighed Questions for Revised Bloom's Taxonomy classifications that are significantly different between Exam Number for Exam Total three.
*P-value < 0.05, **P-value < 0.005.

Table 15. Descriptive statistics for Weighted Questions for all Revised Bloom's Taxonomy classifications across all Exam Totals, Semesters, and Years.

Classification	Mean	Standard Deviation
Remember-Factual	16.1	12.1
Remember-Conceptual	39.4	10.9
Remember-Procedural	0.6	1.5
Understand-Conceptual	24.0	10.9
Apply-Conceptual	1.9	3.2
Apply-Procedural	2.6	4.4
Analyze-Factual	0.05	0.4
Analyze-Conceptual	4.6	9.4
Analyze-Procedural	10.5	10.2
Null	0.3	0.9

Cognitive Domain Classification Results

Weighted Points

Weighted Points significantly differed in classification Analyze between Exam Totals ($p=0.003$; Figure 17). Weighted Points did not significantly differ between Exam Semesters. Classification Analyze was significantly correlated to Exam Year with a correlation coefficient of 0.445 ($p<0.001$; Figure 18). Classifications Remember, Apply, and Analyze significantly differed across Exam Number for Exam Total three ($p<0.001$, $p<0.001$, $p=0.020$; Figure 19). Classification Apply significantly differed across Exam Number for Exam Total five ($p=0.031$; Figure 20). Levels of the Cognitive Domain did not significantly differ across Exam Number for Exam Total eight. Descriptive statistics for Weighted Points for all Cognitive Domain classifications across all Exam Totals, Semesters, and Years can be seen in Table 18.

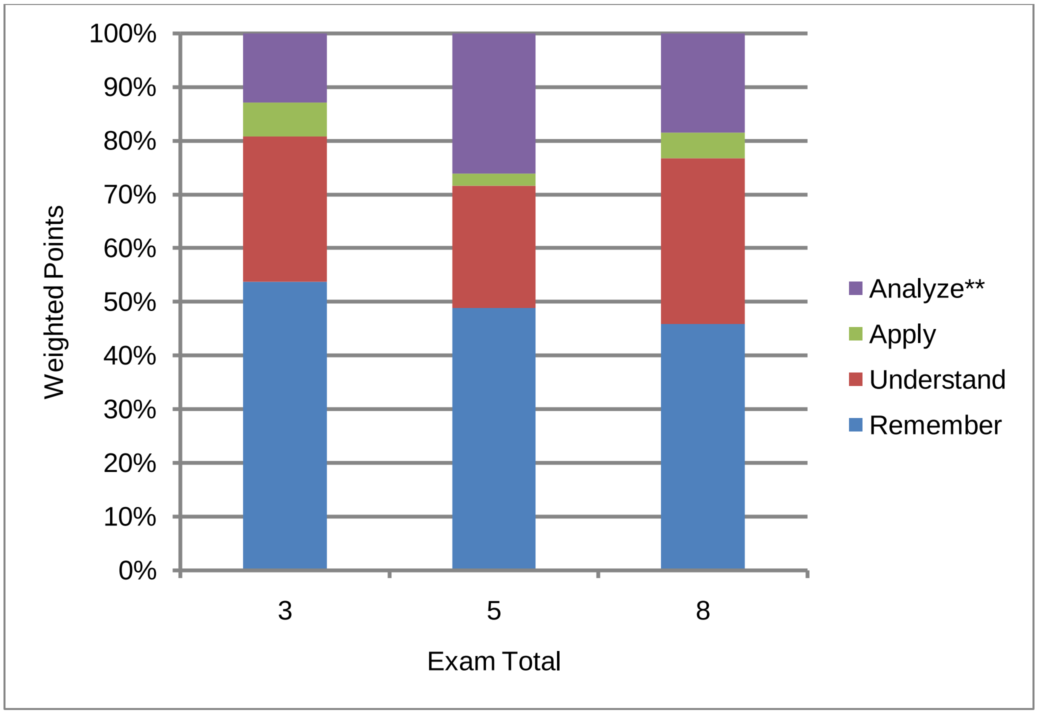

Figure 18. Mean Weighted Points for Cognitive Domain classifications by Exam Total.
**P-value < 0.005

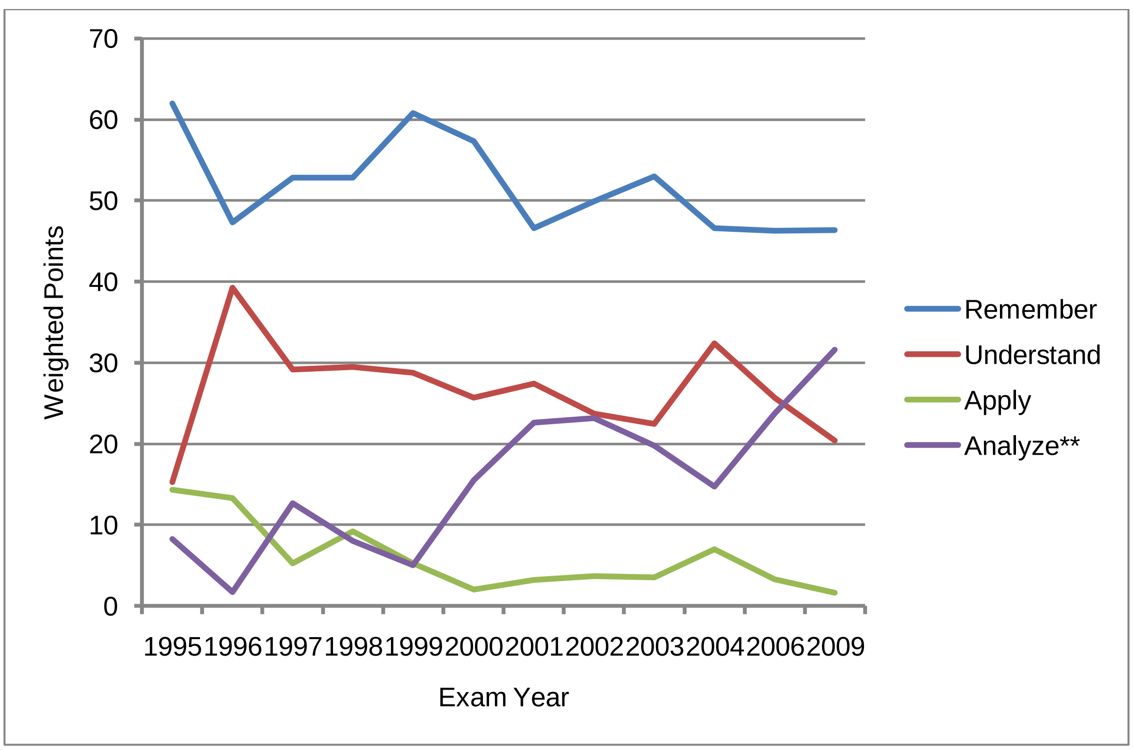

Figure 19. Mean Weighted Points for Cognitive Domain classifications by Exam Year.
** P-value < 0.005

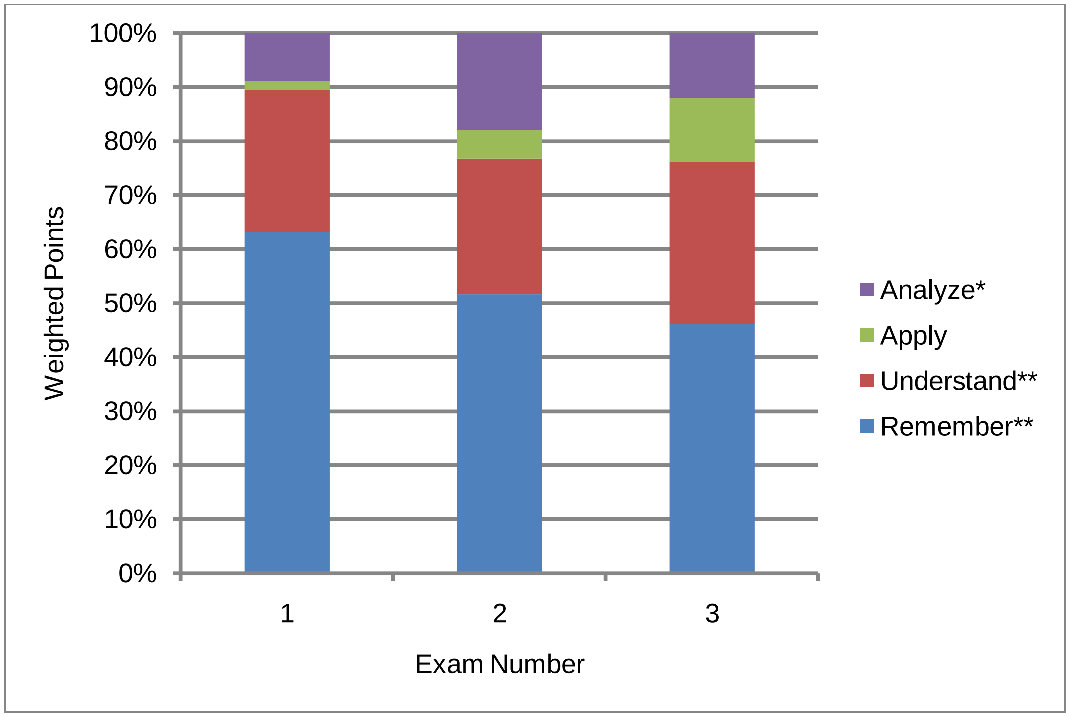

Figure 20. Mean Weighted Points for Cognitive Domain classifications between Exam Number for Exam Total three.
**P-value < 0.005, *P-value < 0.05

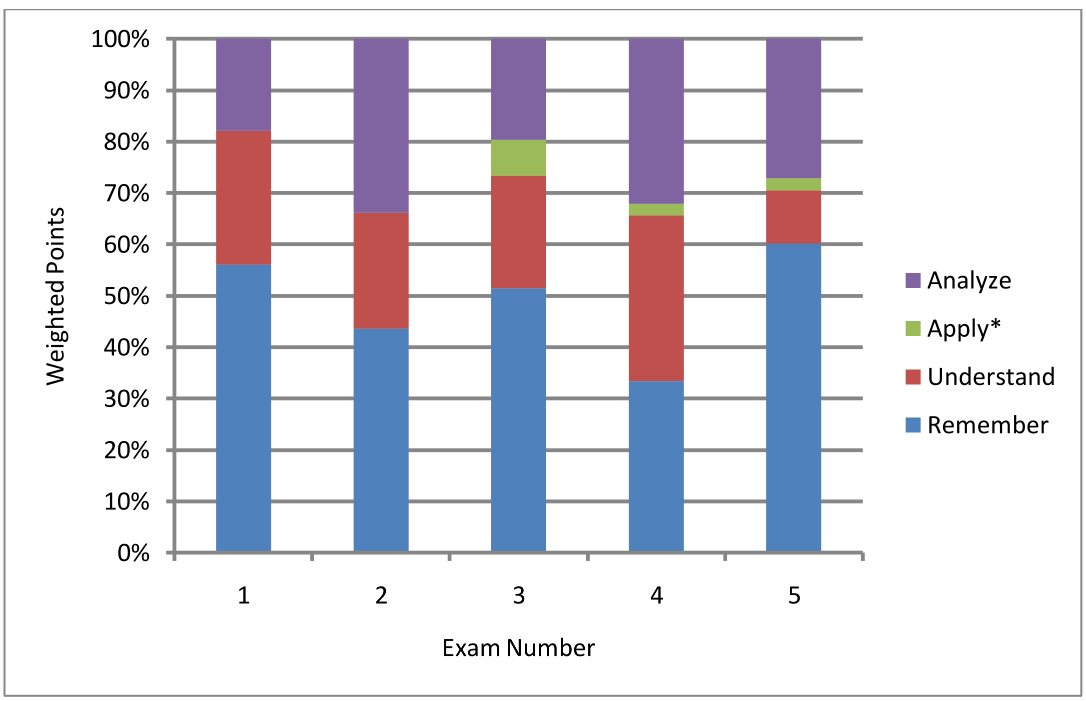

Figure 21. Mean Weighted Points for Cognitive Domain classifications between Exam Numbers for Exam Total five.
*P-value < 0.05

Table 16. Descriptive statistics for Weighted Points for all Cognitive Domain classifications across all Exam Totals, Semesters, and Years.

Classification	**Mean**	**Standard Deviation**
Remember	51.1	13.2
Understand	27.0	11.8
Apply	5.2	7.0
Analyze	16.7	12.5
Null	0.2	0.8

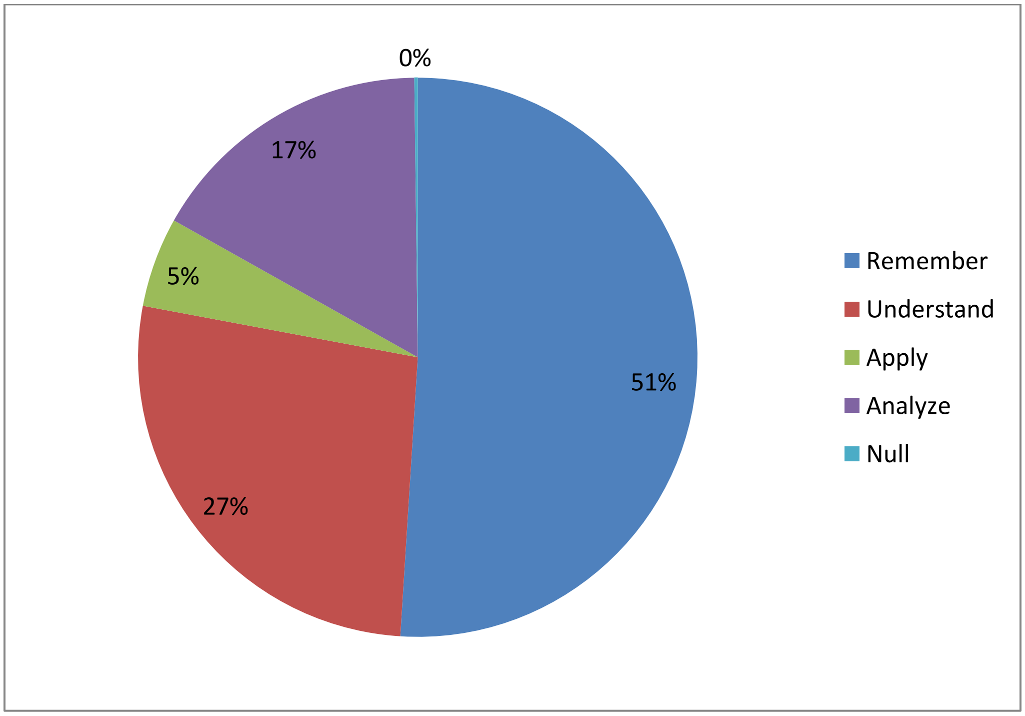

Figure 22. Mean Weighted Points for all Cognitive Domain classifications across all Exam Totals, Semesters, and Years.

Cognitive Domain Classification Results

Weighted Questions

Weighted Questions significantly differed in classification Analyze between Exam Totals ($p<0.001$). Weighted Questions did not significantly differ between Exam Semesters. Classifications Remember and Analyze were significantly correlated to Exam Year with correlation coefficients of 0.306 and 0.432 respectively ($p=0.007$, $p<0.001$; Figure 21). Classifications Remember, Apply, and Analyze significantly differed across Exam Number for Exam Total three ($p<0.001$, $p<0.001$, $p=0.048$). Classification Apply significantly differed across Exam Number for Exam Total five ($p=0.029$). Classifications of the Cognitive Domain did not significantly differ across Exam Number for Exam Total eight. Descriptive statistics for Weighted Questions for all Bloom's Taxonomy classifications across all Exam Totals, Semesters, and Years can be seen in Table 19.

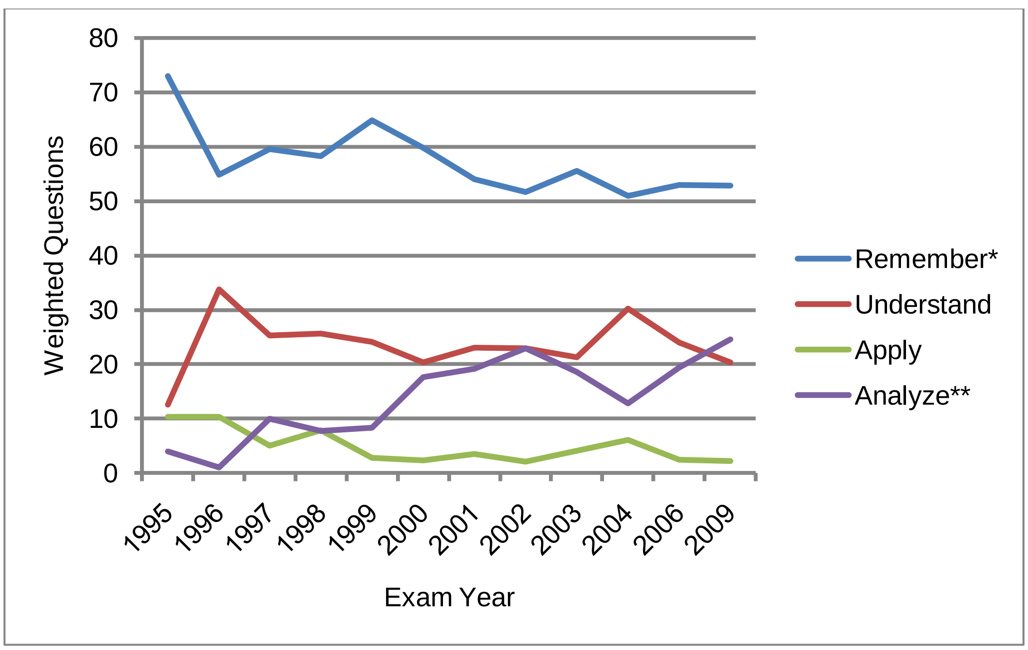

Figure 23. Mean Weighted Questions of Cognitive Domain classifications by Exam Year. *P-value < 0.05, **P-value < 0.005

Table 17. Descriptive statistics for Weighted Questions for all Cognitive Domain classifications across all Exam Totals, Semesters, and Years.

Classification	Mean	Standard Deviation
Remember	56.1	13.3
Understand	24.0	11.0
Apply	4.5	6.0
Analyze	15.1	10.7

Knowledge Dimension Classification Results

Weighted Points

Weighted Points did not significantly differ by Exam Total, Semester, or Exam Year. Classifications Factual and Procedural significantly differed across Exam Number for Exam Total three ($p<0.001$, $p<0.001$; Figure 22). Classifications of the Knowledge Dimension did not significantly differ across Exam Number for Exam Totals five and eight. Descriptive statistics for Weighted Points for all Knowledge Dimension classifications across all Exam Totals, Semesters, and Years can be seen in Table 20.

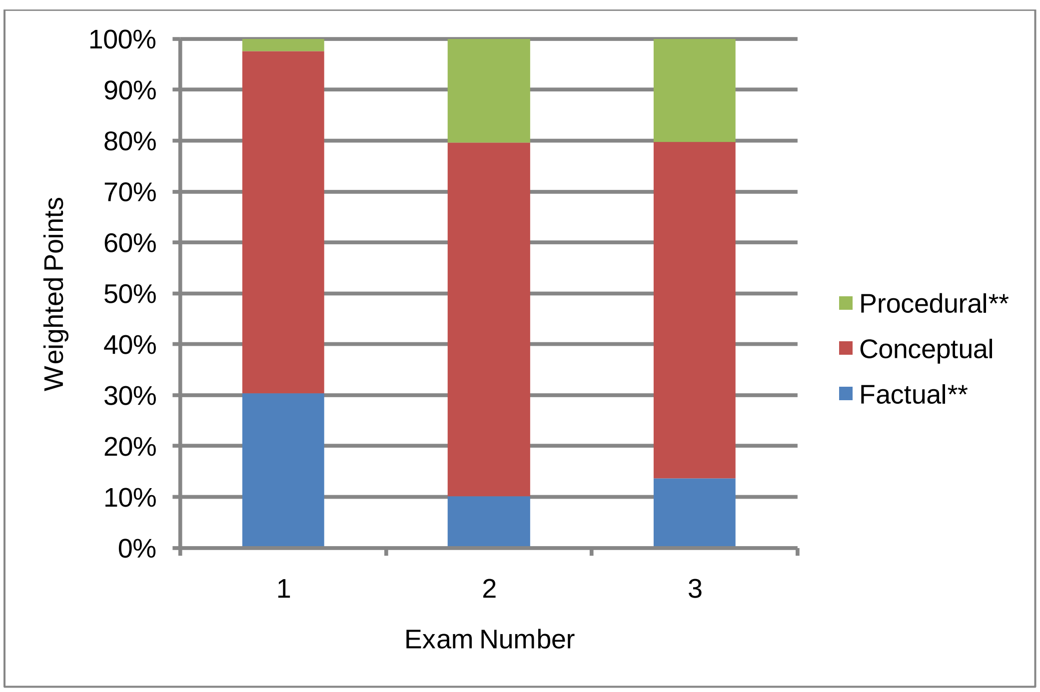

Figure 24. Mean Weighted Points for Knowledge Dimension classifications between Exam Numbers for Exam Total three.

Table 18. Descriptive statistics for Weighted Points for all Knowledge Dimension classifications across all Exam Totals, Semesters, and Years.

Classification	Mean	Standard Deviation
Factual	17.9	16.6
Conceptual	66.5	13.3
Procedural	15.5	13.6

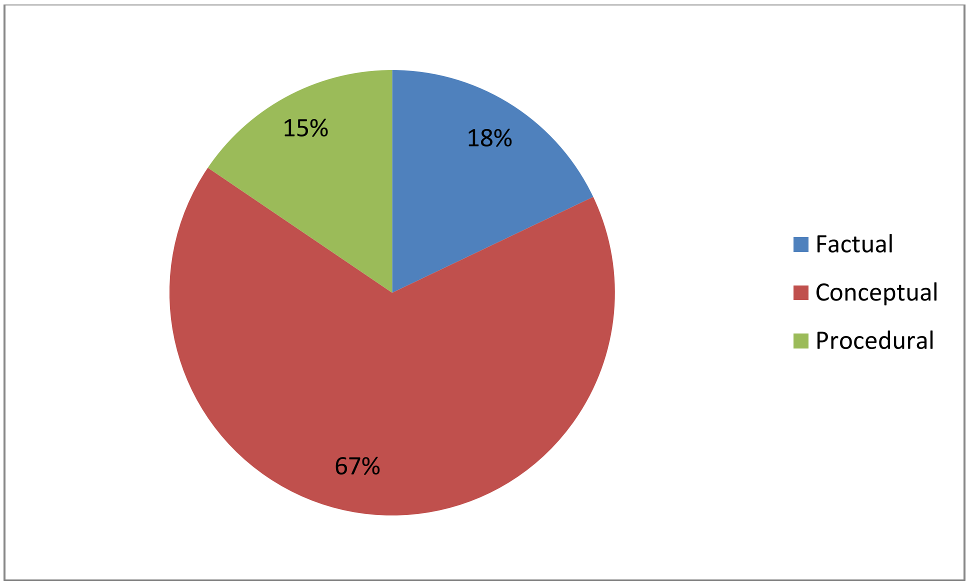

Figure 25. Mean Weighted Points for all Knowledge Dimension classifications across all Exam Totals, Semesters, and Years.

Knowledge Dimension Classification Results

Weighted Questions

Weighted Questions did not significantly differ by Exam Total, Semester, or Exam Year. Classifications Factual and Procedural significantly differed across Exam Number for Exam Total three ($p<0.001$; Figure 23). Classification Procedural significantly differed across Exam Number for Exam Total five ($p=0.042$). Knowledge Dimension classifications did not significantly differ across Exam Number for Exam Total eight. Descriptive statistics for Weighted Questions for all Knowledge Dimension classifications across all Exam Totals, Semesters, and Years can be seen in Table 21.

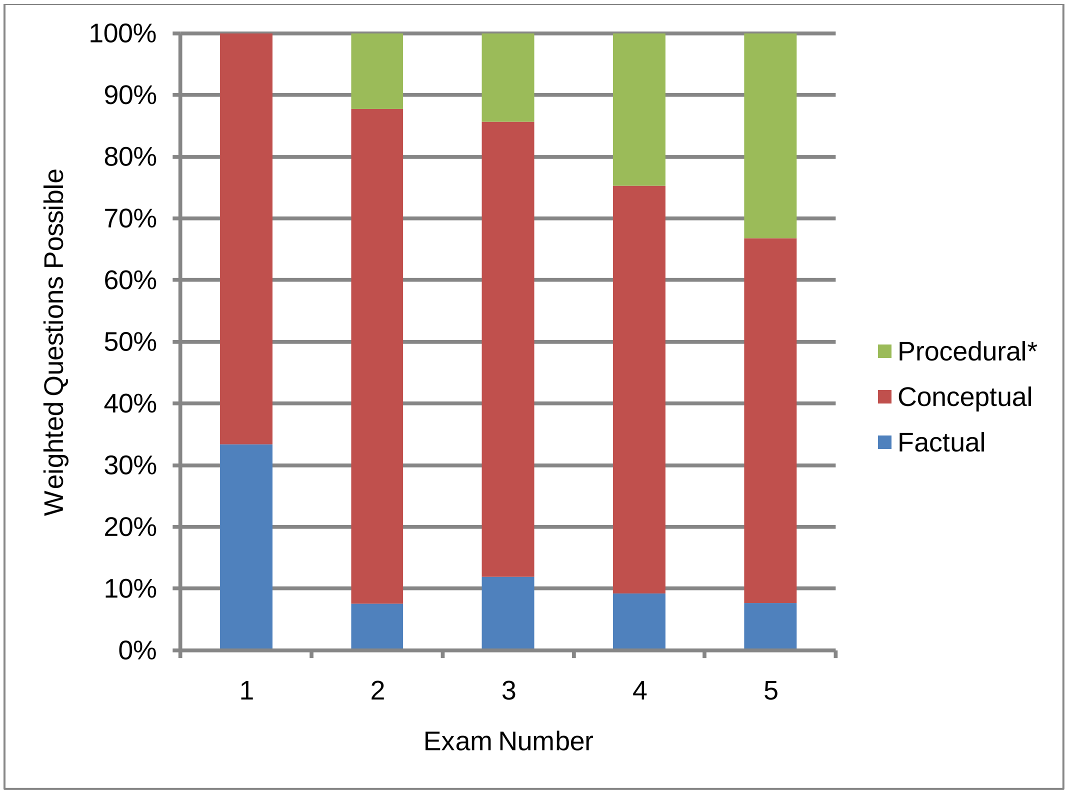

Figure 26. Mean Weighted Questions for Knowledge Dimension classifications between Exam Numbers for Exam Total five.
*P-value<0.05

Table 19. Descriptive statistics for Weighted Questions for all Knowledge Dimension classifications across all Exam Totals, Semesters, and Years.

Classification	**Mean**	**Standard Deviation**
Factual	16.2	12.3
Conceptual	69.8	8.9
Procedural	13.7	10.9

DISCUSSION

Exam Year

Increase in classification Analyze-Conceptual across Exam Year was due to the increase in questions associated with soil profile descriptions (Table 13). However, overall increase in classification Analyze was also due to the increasing complexity of mathematical word problems such that Analyze almost supplanted classification Apply, which formerly dominated mathematical questions. Decrease in classification Remember in Weighted Questions but not in Weighted Points was likely the result of instructor compensation for the increased time required to complete the exam due to the increasing complexity of questions without trying to weight the point values too heavily toward higher cognitive levels. In other words, as the instructor increased the number of question for classification Analyze, the instructor was forced to decrease the number of questions in another classification, Remember, due to time restrictions. In order to prevent the points from being weighted too heavily toward Analyze, the fewer Remember questions had higher point values. The fact that the Knowledge Dimension did not show any significant differences across Exam Year suggested that the course content remained relatively constant over time.

Semester

The lack of significant differences for the Revised Bloom's Taxonomy, Cognitive Domain, and Knowledge Dimension classifications indicated that cognitive complexity and content of the exams did not alter between semesters.

Exam Total

Since only one classification showed a significant difference across Exam Total, it can be concluded that the number of exams in a semester had little effect on the content and cognitive level of the combined questions of those exams. Only classification Analyze significantly differed across Exam Total in both Weighted Points and Weighted Questions, indicating that Exam Total five produced the greatest number of points and questions devoted to the Analyze classification with Exam Total three producing the fewest. This is partially accounted for by the fact that when the content of the course is covered over an increased number exams, exams can be shorter with a greater time allowance for more difficult questions and a greater depth of coverage for specific topics. Thus, an increased number of exams during the semester can facilitate the use of questions at higher cognitive levels and broader knowledge dimensions. However, if that were the only factor, then Exam Total eight would have the greatest Weighted Points and Weighted Questions devoted to the Analyze classification.

Exam Number

While the cumulative questions for the Exam Totals did not have many significant differences, Weighted Points and Weighted Questions for individual exams within Exam Totals showed multiple significant differences. Exam Total three had nineteen significant differences in classifications between Exam Number which included significant differences for both Weighted Points and Weighted Questions. This indicated a high level of imbalance in both cognitive level and content area. However, it should be noted that an imbalance in classification

Remember-Procedural was expected due to the fact that only one question, which is used almost every semester, was placed under that classification (Table 13). Exam Total five showed six significant differences in classification for both Weighted Points and Weighted Questions which indicated a better balance of cognitive level and content than Exam Total three. Exam Total eight did not have any significant differences between Exam Number, indicating that eight exams in a semester produced the best balance of cognitive level and content demands. This is likely the result of the previously discussed effect of increased exam number during the semester.

Future Analysis

Classifications Evaluate, Create, and Metacognitive were not used on any of the exams. To determine whether the instructor needs to alter the cognitive difficulty or knowledge domain for future exams, exam classifications need to be compared with the instructor's learning objectives for the course. Furthermore, correlating question classifications to student performance could offer instructors and department heads perspective on how well students are performing in certain cognitive domains and knowledge dimensions and in what areas students in particular majors and classifications are likely to require assistance when they enter the course.

Thoughts on the Use of the Revised Bloom's Taxonomy

The Revised Bloom's Taxonomy can be thought of as having the same category and subcategory level structure of the original Bloom's Taxonomy. The Knowledge Dimension and Cognitive Domain provide two, category levels, and the Revised Bloom's Taxonomy classification is the subcategory level. Category levels are helpful for understanding general trends, but they do not carry much meaning until seen within the context of the subcategory. For instance, slightly over half of the Weighted Points were devoted to the Remember classification, but

68.4% of those Remember points were in classification Remember-Conceptual. Thus, although the information is coming straight from the notes, the notes are describing conceptual relationships, which may be difficult for students to grasp.

Use of all of the subcategory levels in the classification of learning objectives or questions should not be expected due to the specificity of subcategories and some impracticalities of pairing. For instance, classification Create-Metacognitive is likely to be used infrequently on exams; in such a situation, the student would be asked to create a new product that describes an awareness of his/her own cognitive process. Furthermore, specificity of the subcategory level can create difficulties in analysis such as the Remember-Procedural classification that appeared once every semester on one of the exams. This created a significant difference in classification between Exam Number, but did not generate information of which the instructor was not already aware. Thus, separate analysis of the category levels is recommended to provide classifications that can be analyzed across multiple items.

The Revised Bloom's Taxonomy successfully provided a simple interface for question classification. However, the original Bloom's Taxonomy was frequently referred to due to its emphasis on question classification, which may account for dearth of literature that describes the use of the Revised Taxonomy for question classification. The revised taxonomy also was successful at drawing attention to the need for an increased emphasis on metacognitive knowledge; although, metacognitive knowledge may not be as appropriate on exams as in other areas of the course. Thus, the revised taxonomy was a useful and easy to use tool for question classification that met the authors' goals discussed during the introduction.

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APPPENDICES

Appendix I. Procedures for the Simulator Group for Fall 2009

Soil Conservation

Introduction

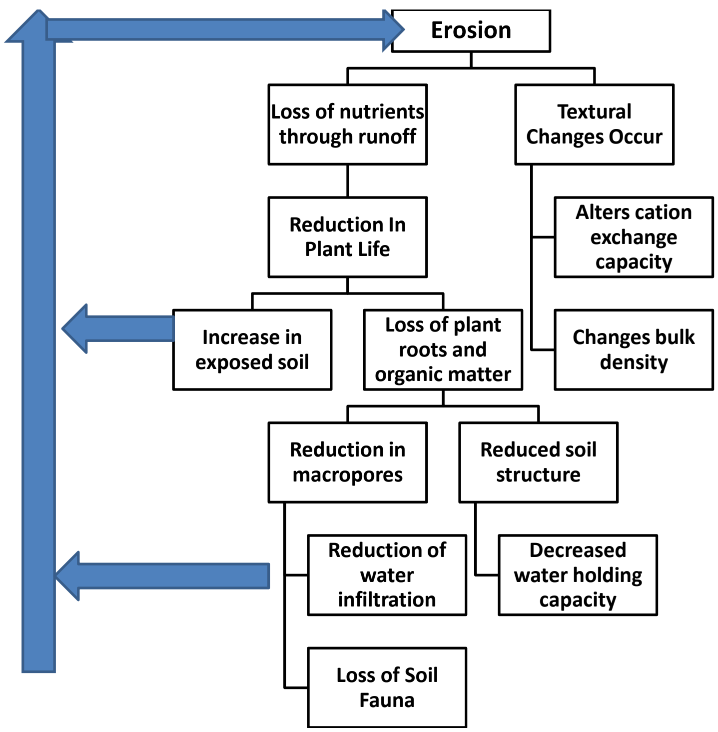
Soil erosion is the detachment, transport and deposition of soil materials. It is a natural process that begins to occur as soon as land uplift has occurred, as a result of a body needing to be at the lowest potential energy possible. Soil will stay where it is formed until there is enough energy in the environment to transport it to a new location. There are many energy sources capable of transporting soil from one location and depositing it in a new location. The primary sources are water, wind, ice, and gravity, none of which we are capable of controlling. However, we can slow down or speed up their effects based on how we manage the land. If we do not protect the soil from our activities, then accelerated erosion can occur causing serious problems to the landscape and our water supplies. Soil erosion has been a major factor in decreasing land productivity and the stability of civilizations, as evidenced in the ancient civilization of Mesopotamia (modern day Iraq) and in the United States during the "Dust Bowl" in the 1930's. Guidelines established by the Natural Resource Conservation Service state the maximum amount of annual erosion should be less than 5 tons/acre-year.

Water Erosion

Three types of water erosion have been identified for fields used for rangeland and crop production, they are sheet, rill, and gully. Sheet and rill erosion are responsible for the majority of the water erosion. Sheet erosion is the uniform loss of soil from a given area. Rill erosion begins in small channels which concentrate runoff water which increases its energy and its capability for erosion. An individual rill does not seem very destructive, but the sum total of all the rills in a field are significant. The channels form rill erosion can be removed with normal tillage operations, but if left unattended, they may develop into gullies. Gully erosion occurs from large channels, which cannot be removed by normal tillage operations. Gullies have the potential to cause serious erosion problems and are the most visible signs of erosion.

Wind Erosion

Wind Erosion is largely a problem in arid and semi-arid areas. Like water erosion, wind erosion is classified into three categories, saltation, creep, and suspension. The largest particles, up to 1 mm in diameter, undergo soil creep which is the transportation of particles by rolling or sliding along the surface of the soil. Creep generally accounts for 5-25% of wind erosion. Medium sized particles, .05-.5 mm in diameter, are responsible for saltation which is the movement of the particle by a series of short bounces. Saltation is largely responsible for the detachment of particles in wind erosion. This accounts for 50-90% of wind erosion. Finally, fine particles which are less than .05 mm in diameter are transported by suspension in which the particles move parallel to the ground surface and upward. Suspended particles may travel for great distances. Suspension accounts for 5-15% of wind erosion. A 15 mph wind is needed to initiate soil movement.



Erosion Spiral

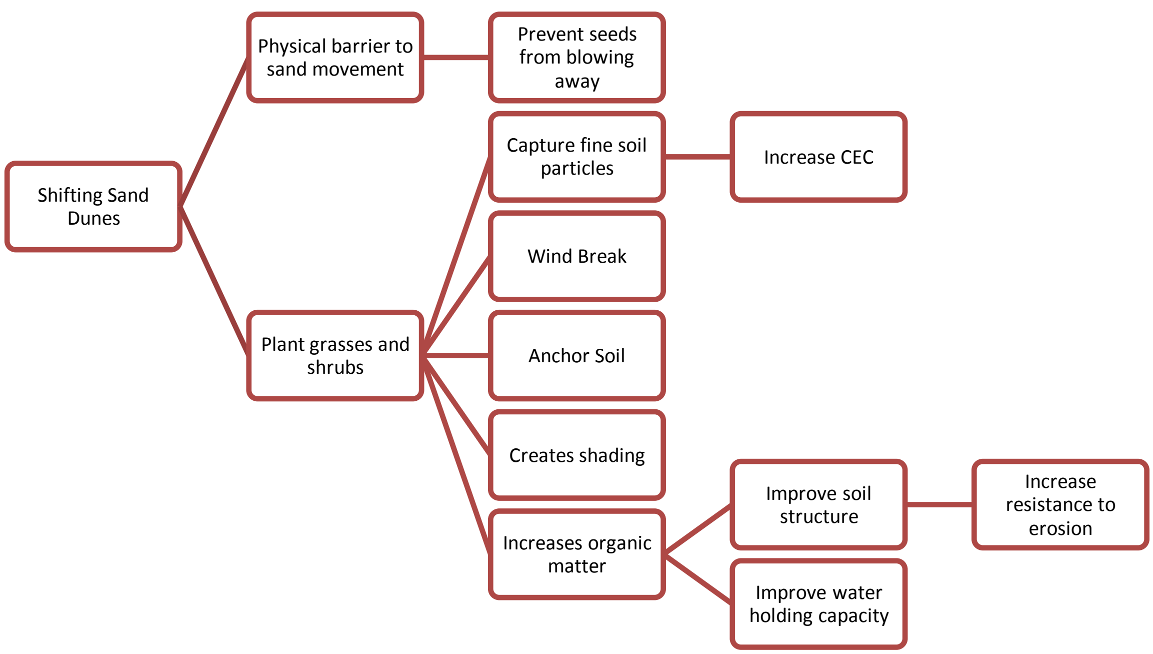
Erosion creates a downward spiral of soil degradation from which it is hard to recover. It begins with the loss of topsoil and nutrients due to the runoff or wind erosion. This creates a less favorable environment for plant growth which causes a reduction in plant life. The reduction in plant life is what really sends this spiral out of control. With fewer plants, there is less cover on the soil surface which increases erosion. The loss of plants will reduce root penetration and organic matter in the soil. This will reduce the number of macropores which, in turn, slows water infiltration and creates a less favorable habitat for soil fauna. The loss of organic matter will also decrease soil structure which will reduce water holding capacity and make the soil aggregates more susceptible to erosion. Long term erosion can change the texture of a soil, altering the cation exchange capacity and the bulk density.

Detrimental Effects of Water Erosion

As well as reducing the productivity of the land, erosion has numerous detrimental effects on water bodies resulting from sedimentation and eutrophication. Eutrophication is the result of excess nutrients running off into a body of water which causes an algal bloom. When the algae from the algal bloom die and are decomposed by microbial organisms, the high respiration rate of these organisms causes a depletion of oxygen in the body of water. Low oxygen causes high fish kills. Water erosion can also cause mudslides, seed wash out, structural damage, and the transport of pesticides into bodies of water.

Detrimental Effects of Wind Erosion

Wind erosion can cause problems with air quality, abrasion, and necessitate expensive clean up projects after dust storms. In arid regions, unchecked wind erosion can eventually lead to desertification with shifting sand dunes. It is difficult to reestablish plant life in such areas due to limited water resources, salinization of the soil, changes in soil texture, diminished soil nutrients, and unstable seed beds.



Water Erosion Control

The key factor in reducing water erosion is to reduce the detachment of soil by raindrop impact. Raindrops act as little bombs, detaching soil particles through energy transfer. The best way to reduce this impact is to keep a cover on the surface of the soil. The covering, either plant residues or permanent crops, will absorb the kinetic energy of the raindrop and prevent soil detachment. As you will see from the simulator, no-tillage systems which maintain a cover crop on the soil surface can significantly reduce the amount of erosion. Over time, they will also increase soil organic matter which improves soil structure and water holding capacity. In traditional tillage systems where a surface residue cannot be maintained, water erosion can be slowed using terraces or strip cropping. Terraces can be used to divert runoff water down a grassed waterway. The terrace will slow the velocity of water travelling across the field and ideally, divert it to a vegetated waterway which can capture sediment. Strip cropping works in a similar way to terraces. Strips of permanent crop are alternated with strips of tilled ground. The strips are placed perpendicular to the slope of the land. When runoff occurs, the strips of permanent crop will capture sediment and reduce the velocity of the water flowing downhill.

Wind Erosion Control

Like water erosion, the best way to control wind erosion is by preventing detachment. If the soil is wet enough, the cohesive and adhesive properties of water are sufficient to keep the soil in place. However, bare, wet soil will quickly dry out under a hot, dry wind which makes this approach impractical. Wind erosion can be controlled using wind breaks or soil cover. Wind breaks such as dense trees or shrubs which run perpendicular to the prevailing wind will slow the velocity of the wind and cause it to go up and over a certain space of land. These wind breaks can also filter suspended soil particles. Maintaining a soil cover, as seen with no till, will also reduce wind erosion. It increases the roughness of the soil surface, helps keep the soil moist, and can eventually improve soil aggregate stability through organic matter addition.

Revised Universal Soil Loss Equation

The revised universal soil loss equation, RUSLE, is used to estimate soil loss in tons acre^{-1} based on five factors. This is symbolized in the equation

A=RKLSCP

where A is soil loss in tons acre^{-1}. R is the climatic factor which takes into account the quantity and intensity of the rainfall at a given location based on historical data. K is the erodibility factor which takes into account the susceptibility of a soil to erode. Generally, as a soil's silt content increases, it's susceptibility to water erosion increases due to silt's small size and non-cohesive properties. LS is the topography factor which is a combination of the length and steepness of the slope. Typically, as length and steepness increase, so does potential water erosion due to increasing energy of runoff water. C is the cropping factor which takes into account the crop that is grown and how the crop residue is managed. P represents support or structural practices implemented within a field. P factors include row orientation, strip cropping, terraces, and other improvements to reduce erosion. The RUSLE is a more complex, computer model based off of the original USLE. So, for the purposes of this class, calculations will be done with the original USLE. For the USLE, all of the factors are listed in tables and multiplied to obtain the answer in tons of soil loss per acre.

Revised Wind Erosion Prediction Equation (RWEQ)

RWEQ is summarized in the equation

$E = f(ICKLV)$

This means that the loss of soil in tons/acre/year is a function of ICKLV. I is the soil erodibility factor which is determined by the properties of the soil and the slope. It also takes into account the presence of a soil crust and cementing agents. C is the climatic factor which takes into account wind velocity, soil temperature, and precipitation. K is the soil-ridge-roughness factor which considers the cloddiness of the soil surface. Wind erosion decreases with increasing surface roughness. L is the width of field factor which is the width of a field in the downwind direction. V relates to the amount and type of vegetative cover. RWEQ, like the RUSLE equation, is integrated into a computer program and is more accurate than the original Wind Erosion Equation.

Procedure

1. Your team will be assigned a treatment.
2. Calculate the area of your erosion plot and record the results in Table 1.
3. The rainfall simulator will be started and raining down a 2 in/hour rainfall. Record the time of the rainfall event.
4. After the rainfall event, measure the depth of the water in the collection container. Record the depth in table 1.
5. Measure the radius of the collection container and calculate the volume of water collected. $A = \pi r^2 h$. Record the results in table 1.
6. Stir the water to mix up the sediment and fill your collection bottle.

7. After returning to the lab, pre-weigh a piece of filter paper.
8. Place the filter paper in the vacuum funnel and pre-wet it with the vacuum turned on.
9. Shake your bottle to remix the sediment, and add 25mL of runoff using the pipet aid to the filter paper.
10. Filter the runoff water using the vacuum. If 25mL of water is not enough to create a measurable amount of sediment, then add another 25mL.
11. Pre-weigh a watch glass and place the filter paper on the watch glass for drying in the microwave.
12. Microwave the filter paper.
13. Remove the dry filter paper plus sediment and record the weight.
14. Calculate how much erosion occurred on the erosion plot and record in table 2.

Table 1. Soil erosion data collection at site	
Sample	Measurement
Treatment	
Erosion plot length X width	101.6 cm X 53.34 cm
Total area of erosion plot	5419.34 cm^2
Diameter of bucket	29.21 cm
Depth of water	
Total amount of runoff collected (mL)	

Table 2. Soil erosion data collected in lab	
Weight of filter paper (g)	
mL of water filtered	
Weight of watch glass	
Weight of soil + filter paper + watch glass(g)	
Weight of soil (g)	
Grams of soil / cm^3 water filtered	

Table 3. Soil erosion data for all treatments	
Treatment	Soil Loss (tons/acre)
1: Bare	
2: Terrace	
3: Strip Crop	
4: Residue	
5: Grass	

Procedure for Wind Erosion Simulator

1. You will be assigned a treatment from the table below.
2. After you treatment has been eroded from the wind tunnel, collect the sediment in the sand trap and weigh it.
3. Given the area of your treatment, calculate the soil loss in tons/acre.

Treatment	Weight of collected soil in grams	Soil Loss Tons/Acre
Bare sand		
Sand with wind break		
Bare organic		
Organic with wind break		

1. If the field you were measuring had received 11 additional rainfalls for the rest of the year of the intensity and duration experienced today, would it meet the maximum established by the Natural Resource Conservation?

   ____

2. Of the five factors of the universal soil loss equation, which has the greatest impact on erosion? Why?

   ____

   ____

3. How does the reduction of plant life due to soil erosion increase erosion to create a spiral of degradation?

   ____

   ____

4. Which two types of water erosion are considered to be the most damaging?

   ____

5. What is eutrophication?

   ____

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6. What is the detaching agent of water erosion? Of wind erosion?

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7. Why should a producer till or plant strip crops perpendicular to the slope instead of parallel to the slope to reduce water erosion?

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8. Name one way to reduce erosion by wind, and explain how it works.

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9. Which soil particles are carried away by suspension? How does this affect soil properties?

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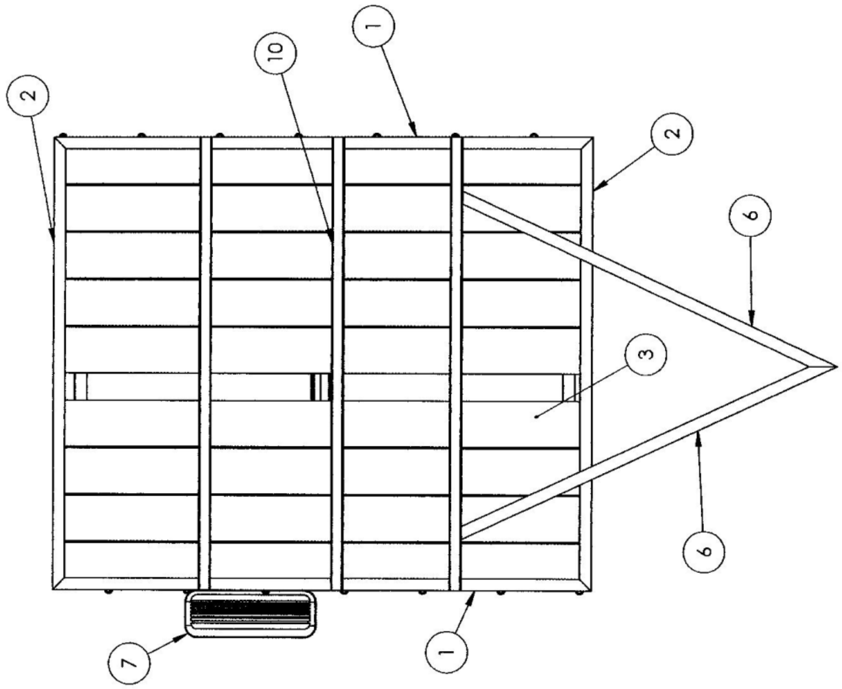
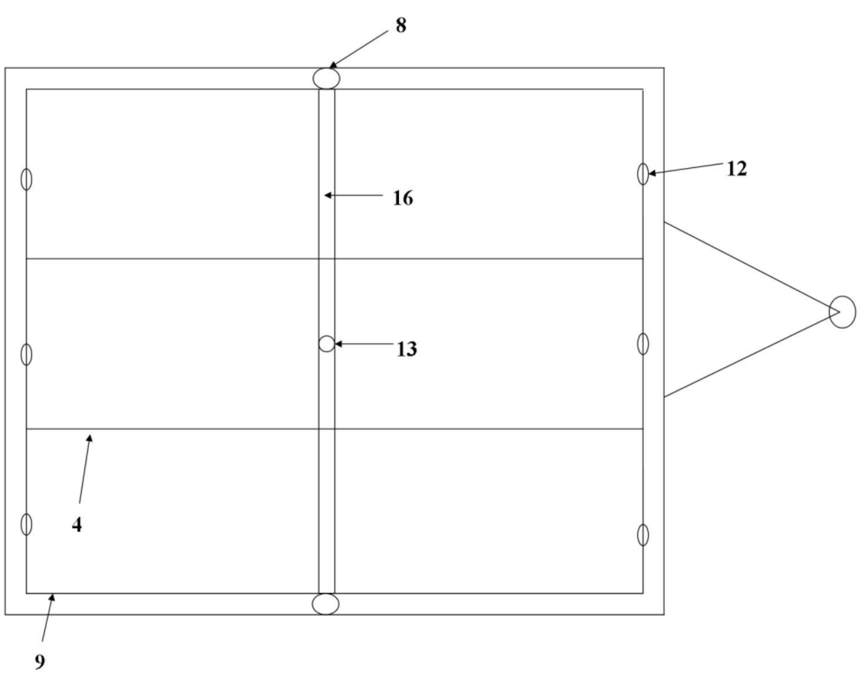
Appendix II. Rainfall simulator pictures and design plans.

Item Number	Part	Quantity	Notes
1	80 X 2 ANGLE	2	2.3 meter (90.83 inches) long
2	73.5 X 2 ANGLE	2	1.95 meter (76.83 inches) long
3	BOARDS	12	
4	TREATMENT BOXES	6	The treatment boxes are approximately 100.6 cm X 64 cm (39.6 inches X 25.2 inches) with holes drilled to accommodate a runoff spout.
5	TIRE	2	
6	HITCH TUBE	2	
7	FENDER	1	
8	TELESCOPING POLE	2	The simulator is run at the maximum pole height, which is 2.31 m (91 inches).
9	BOX FRAME	1	The box frame is angled at a 5% slope.
10	CROSS ANGLE	3	1.96 m (77 inches)
11	TARP LOOP	2	
12	RUNOFF SPOUT	1	
13	SPRAY NOZZLE	1	Spraying Systems Company Stock Number: ½-HH-SS-50W
14	TARP FRAME	2	
15	POLE MOUNT	1	
16	NOZZLE MOUNT	1	1.78 m (70 inches) long

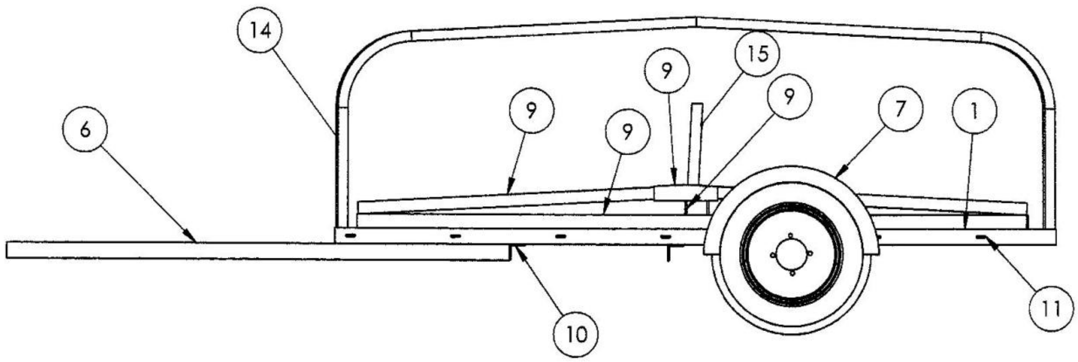
Aerial View of Trailer without Treatment Boxes, Box Frame, or Water Dispensing System



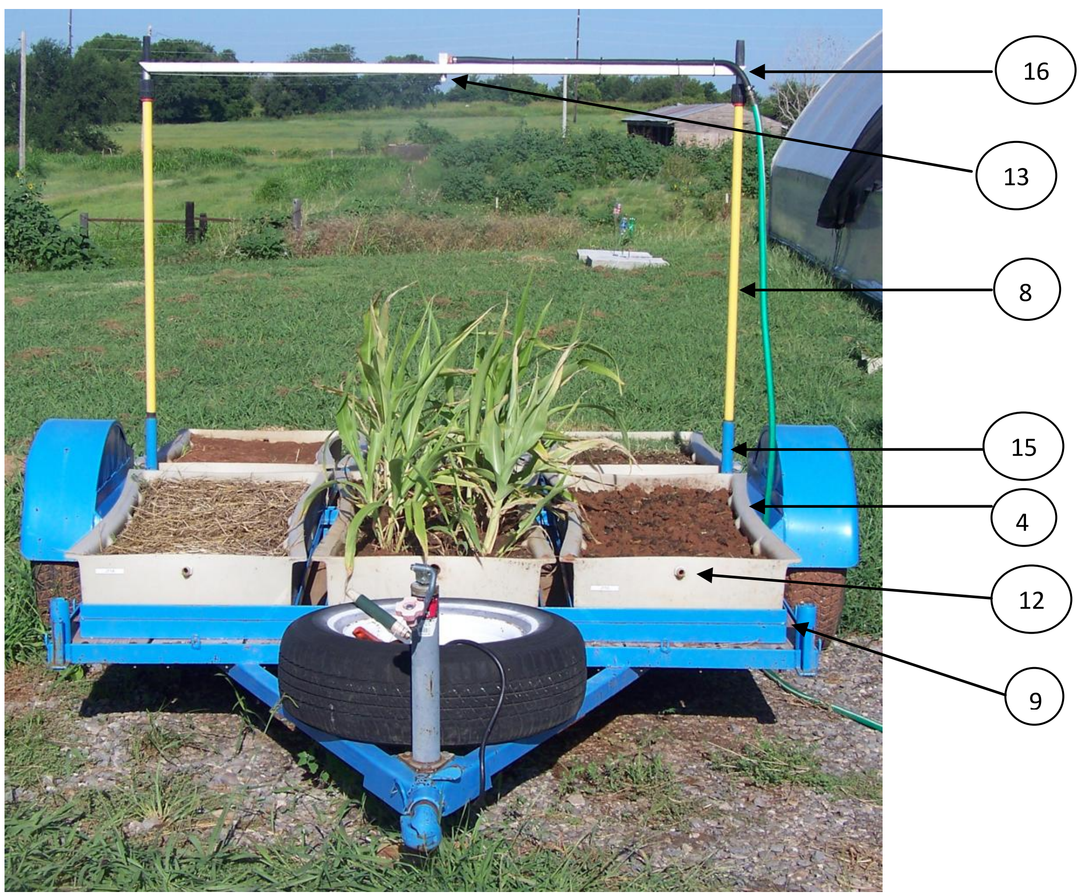
Aerial View of Rainfall Simulator with Treatment Boxes, Box Frame, and Water Dispensing System



Side View of Trailer with Box Frame and without Treatment Boxes or Water Dispensing System



Rainfall Simulator. Poles are not at the maximum height.

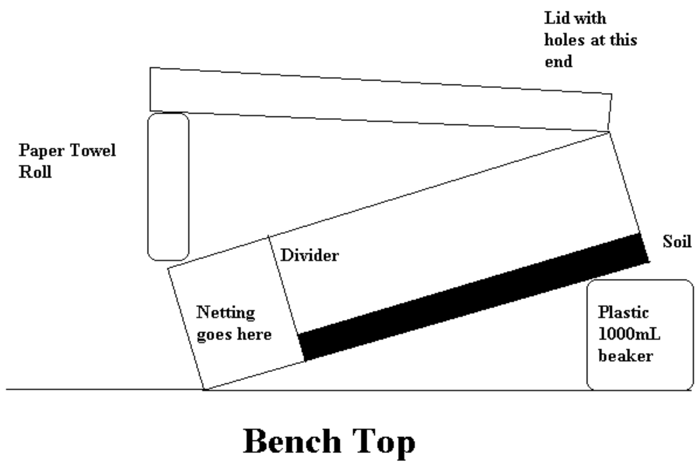


Treatment Box Seen with Tubing and Collection Container

Appendix III. Procedures for the Lecture Group for the Spring 2010 semester.

In-Lab Directions

1. Make sure that your box is set up as diagrammed below. The divider should be on the lowest notch. The netting should be in the end of the container. The plastic beaker should be at the end of the box to create a slope, and the angle of the rain lid should be dictated by a paper towel roll.



2. Remove the divider. Press the edge of the sand over the netting to ensure that the sand will flow over the netting instead of under it.

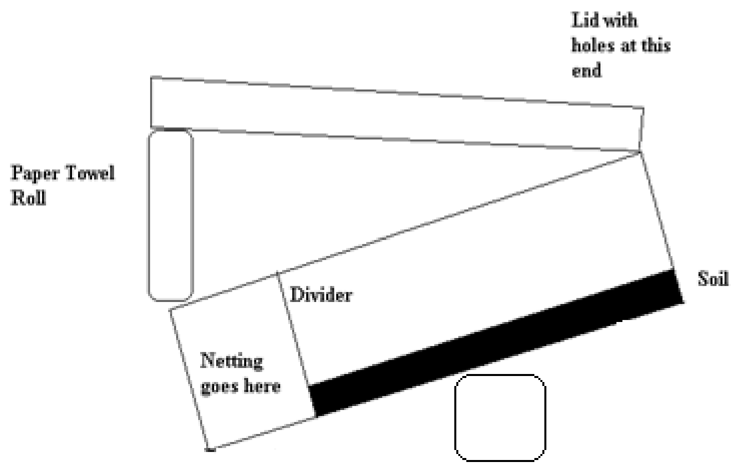
3. Fill up a graduated cylinder with water. Empty it 10mL at a time into the rain lid. Make sure that the lid has fully drained before adding more water. This is a low intensity rainfall. Collect the sediment and record the volume.

4. Reset the soil box and refill the graduated cylinder. This time, empty the cylinder all at once to simulate a high intensity rainfall. Record the volume of sediment collected.

5. Reset the box and refill the graduated cylinder. Push your plants into the soil. Try to arrange them for maximum soil conservation. Use the high intensity rainfall again and record the volume of sediment collected.

6. Reset the box and refill the graduated cylinder. Add both “terraces” and plants to the soil. Try to arrange them for maximum soil conservation. Use the high intensity rainfall again and record the volume of sediment collected.

7. Reset the box and refill the graduated cylinder. Now move the plastic beaker further under the box (as far as it will go and still be stable) to create a steeper slope. Use the high intensity rainfall again and record the volume of sediment collected.



Trial	Soil Volume (mL)
Low Intensity Rainfall	
High Intensity Rainfall	
Cropping	
Cropping and Terraces	
Increased Slope	

Questions:

Complete page 47 in the lab manual.

1. Why did the high intensity rainfall increase the rate of erosion?

____

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2. What acts as the detaching agent in water erosion? What acts as the detaching agent in wind erosion?

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3. How did the “crops” reduce water erosion? How would they also reduce wind erosion?

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4. How does soil loss from water erosion create a spiral of soil erosion?

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5. What are the factors of the wind erosion equation?

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6. Why is no-till effective at controlling both water and wind erosion?

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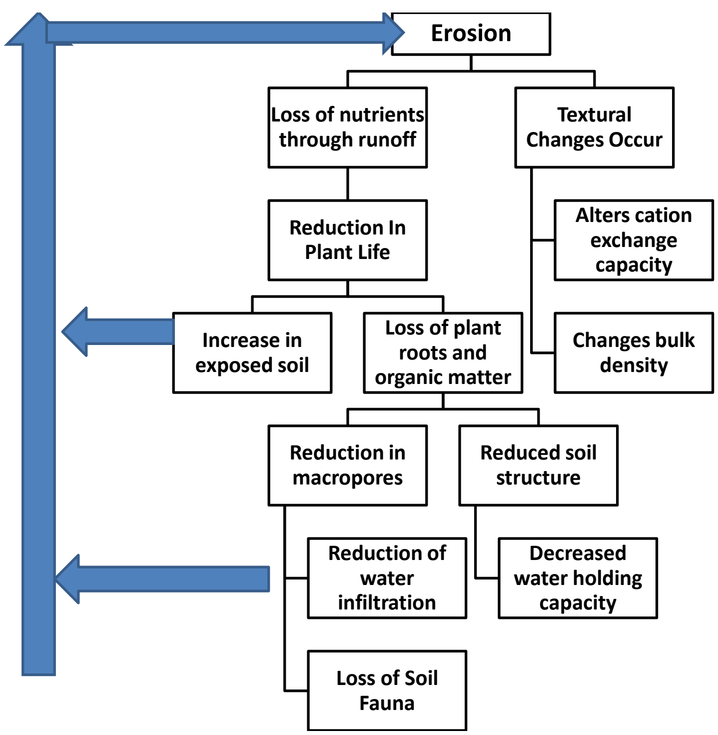
Appendix IV. Simulator Group procedures for the Spring 2010 semester.

Soil Conservation

Erosion Spiral

Erosion creates a downward spiral of soil degradation from which it is hard to recover. It begins with the loss of topsoil and nutrients due to the runoff or wind erosion. This creates a less favorable environment for plant growth which causes a reduction in plant life. The reduction in plant life is what really sends this spiral out of control. With fewer plants, there is less cover on the soil surface which increases erosion. The loss of plants will reduce root penetration and organic matter in the soil. This will reduce the number of macropores which, in turn, slows water infiltration and creates a less favorable habitat for soil fauna. The loss of organic matter will also decrease soil structure which will reduce water holding capacity and make the soil aggregates more susceptible to erosion. Long term erosion can change the texture of a soil, altering the cation exchange capacity and the bulk density.



Revised Universal Soil Loss Equation

The revised universal soil loss equation, RUSLE, is used to estimate soil loss in tons per acre based on five factors. This is symbolized in the equation

A=RKLSCP

where A is soil loss in tons per acre. R is the climatic factor which takes into account the quantity and intensity of the rainfall at a given location based on historical data. K is the erodibility factor which takes into account the susceptibility of a soil to erode. Generally, as a soil's silt content increases, it's susceptibility to water erosion increases due to silt's small size and non-cohesive properties. LS is the topography factor which is a combination of the length and steepness of the slope. Typically, as length and steepness increase, so does potential water erosion due to increasing energy of runoff water. C is the cropping factor which takes into account the crop that is grown and how the crop residue is managed. P represents support or structural practices implemented within a field. P factors include row orientation, strip cropping, terraces, and other improvements to reduce erosion. The RUSLE is a more complex, computer model based off of the original USLE. So, for the purposes of this class, calculations will be done with the original USLE. For the USLE, all of the factors are listed in tables and multiplied to obtain the answer in tons of soil loss per acre.

Water Erosion Control

Producers have little control over factors R, K, and LS; therefore, water erosion control is largely controlled by changing C and P factors. The key factor in reducing water erosion is to reduce the detachment of soil by raindrop impact. Raindrops act as little bombs, detaching soil particles through energy transfer. The best way to reduce this impact is to keep a cover on the surface of the soil. The covering, either plant residues or permanent crops, will absorb the kinetic energy of the raindrop and prevent soil detachment. As you will see from the simulator, no-tillage systems which maintain a cover crop on the soil surface can significantly reduce the amount of erosion. Over time, they will also increase soil organic matter which improves soil structure and water holding capacity. In traditional tillage systems where a surface residue cannot be maintained, water erosion can be slowed using terraces or strip cropping. Terraces can be used to divert runoff water down a grassed waterway. The terrace will slow the velocity of water travelling across the field and ideally, divert it to a vegetated waterway which can capture sediment. Strip cropping works in a similar way to terraces. Strips of permanent crop are alternated with strips of tilled ground. The strips are placed perpendicular to the slope of the land. When runoff occurs, the strips of permanent crop will capture sediment and reduce the velocity of the water flowing downhill.

Revised Wind Erosion Prediction Equation (RWEQ)

RWEQ is summarized in the equation

$E = f(ICKLV)$

This means that the loss of soil in tons/acre/year is a function of ICKLV. I is the soil erodibility factor which is determined by the properties of the soil and the slope. It also takes into account the presence of a soil crust and cementing agents. C is the climatic factor which takes into account wind velocity, soil temperature, and precipitation. K is the soil-ridge-roughness factor which considers the cloddiness of the soil surface. Wind erosion decreases with increasing surface roughness. L is the width of field factor which is the width of a field in the downwind direction. V relates to the amount and type of vegetative cover. RWEQ, like the RUSLE equation, is integrated into a computer program and is more accurate than the original Wind Erosion Equation.

Wind Erosion Control

Wind erosion is problematic in arid areas with large, level land masses, steady prevailing winds, and dry, loose soil that is sparsely covered. Like water erosion, the best way to control wind erosion is by preventing detachment. If the soil is wet enough, the cohesive and adhesive properties of water are sufficient to keep the soil in place. However, bare, wet soil will quickly dry out under a hot, dry wind which makes this approach impractical. Wind erosion can be controlled using wind breaks or soil cover. Wind breaks such as dense trees or shrubs which run perpendicular to the prevailing wind will slow the velocity of the wind and cause it to go up and over a certain space of land. These wind breaks can also filter suspended soil particles. Maintaining a soil cover, as seen with no till, will also reduce wind erosion. It increases the roughness of the soil surface, helps keep the soil moist, and can eventually improve soil aggregate stability through organic matter addition.

Guidelines established by the Natural Resource Conservation Service state the maximum amount of annual erosion should be less than 5 tons/acre-year.

Rainfall Simulator Procedure

1. Your team will be assigned a treatment.
2. Make sure that your materials are properly attached and set up

3. The rainfall simulator will be started and raining down a 2 in/hour rainfall. Record the time of the rainfall event.
4. After the rainfall event, measure the depth of the water in the collection container. Record the depth in Table 1.
5. Measure the radius of the collection container and calculate the volume of water collected. $V = \pi r^2 h$. Record the results in Table 1.
6. Stir the water to mix up the sediment and fill your collection bottle.
7. After returning to the lab, pre-weigh a piece of filter paper.
8. Place the filter paper in the vacuum funnel and pre-wet it with the vacuum turned on.
9. Shake your bottle to remix the sediment, and add 25mL of runoff using the pipet aid to the filter paper.
10. Filter the runoff water using the vacuum. If 25mL of water is not enough to create a measurable amount of sediment, then add another 25mL.
11. Pre-weigh a watch glass and place the filter paper on the watch glass for drying in the microwave.
12. Microwave the filter paper.
13. Remove the dry filter paper plus sediment and record the weight.
14. Calculate how much erosion occurred on the erosion plot and record in Table 2.

Table 1. Soil erosion data collection at site	
Sample	Measurement
Treatment	
Erosion plot length X width	101.6 cm X 53.34 cm
Total area of erosion plot	5419.34 cm^2
Diameter of bucket	
Depth of water	
Volume of Water collected (cm^3) = $V = \pi r^2 h$	

Table 2. Soil erosion data collected in lab	
Weight of filter paper (g)	
mL of water filtered	
Weight of watch glass	
Weight of soil + filter paper + watch glass(g)	
Weight of soil (g)	
Grams of soil / cm^3 water filtered	

Table 3. Soil erosion data for all treatments	
Treatment	Soil Loss (tons/acre)
1: Bare	
2: Terrace	
3: Strip Crop	
4: Residue	
5: Grass	

Procedure for Wind Erosion Simulator

1. You will be assigned a treatment from the table below.
2. Each treatment will be eroded in the wind tunnel for four minutes
3. After you treatment has been eroded from the wind tunnel, collect the sediment in the sand trap and weigh it.
4. The treatment area is 24 inches X 2 inches
5. Given the area of your treatment, calculate the soil loss in tons/acre hour.

Treatment	Weight of collected soil in grams	Soil Loss Tons/Acre hour
Bare sand with crust		
1: Bare sand with terraces		
2: Bare sand with wind break		
3: Bare sand with sugar spray (organic matter)		
4: Perpendicular crop		
5: Perpendicular crop with residue		

1. Of the five factors of the universal soil loss equation, which factors do producers have the most control over?

   ____

   ____

2. Why are silt sized particles the most erodible particles in water erosion?

   ____

   ____

3. How does the reduction of plant life due to soil erosion create a spiral of degradation?

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4. Which two types of water erosion are considered to be the most damaging?

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5. What is eutrophication?

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6. What is the detaching agent of water erosion? Of wind erosion?

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7. Name one way to reduce water erosion and explain why it is effective.

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____

8. Name one way to reduce erosion by wind, and explain why it is effective.

____

____

9. Which soil particles are carried away by suspension? How does this affect soil properties?

____

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10. What are the five factors of the wind erosion equation, and what do they stand for?

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Appendix V. Bloom’s Taxonomy of Educational Objectives.

1.00 Knowledge
- 1.10 Knowledge of Specifics
  - 1.11 Knowledge of Terminology
  - 1.12 Knowledge of Specific Facts
- 1.20 Knowledge of Ways and Means of Dealing with Specifics
  - 1.21 Knowledge of Conventions
  - 1.22 Knowledge of Trends and Sequences
  - 1.23 Knowledge of Classification and Categories
  - 1.24 Knowledge of Criteria
  - 1.25 Knowledge of Methodology
- 1.30 Knowledge of the Universals and Abstractions in a Field
  - 1.31 Knowledge of Principles and Generalizations
  - 1.32 Knowledge of Theories and Structures

2.00 Comprehension
- 2.10 Translation
- 2.20 Interpretation
- 2.30 Extrapolation

3.00 Application

4.00 Analysis
- 4.10 Analysis of Elements
- 4.20 Analyses of Relationships
- 4.30 Analysis of Organizational Principles

5.00 Synthesis
- 5.10 Production of a Unique Communication
- 5.20 Production of a Plan, or Proposed Set of Operations
- 5.30 Derivation of a Set of Abstract Relations

6.00 Evaluation
- 6.10 Judgments in Terms of Internal Evidence
- 6.20 Judgments in Terms of External Criteria

Appendix VI.

CARWILE SERIES

The Carwile series consists of very deep, poorly drained, slowly permeable soils on terraces of the uplands. They are formed in loamy alluvium or aeolian sediments of Pleistocene age. These soils occur on nearly level or concave uplands of the Central Rolling Red Plains (MLRA 78C) and Central Rolling Red Prairies (MLRA 80A). Water runs off the surface at a negligible or low rate or is ponded. Slope ranges from 0 to 1 percent.

TAXONOMIC CLASS: Fine, mixed, superactive, thermic Typic Argiaquolls

TYPICAL PEDON: Carwile loam--cultivated. (Colors are for moist soils unless otherwise stated.)

Ap--0 to 6 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; weak fine granular structure; hard, friable; many fine roots; slightly acid; abrupt smooth boundary. (0 to 8 inches thick)

A1--6 to 10 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; moderate fine granular structure; hard, friable; many fine roots; slightly acid; gradual smooth boundary. (4 to 14 inches thick)

BA--10 to 15 inches; very dark grayish brown (10YR 3/2) sandy clay loam, dark grayish brown (10YR 4/2) dry; few fine distinct yellowish red redoximorphic accumulations; weak fine subangular blocky structure; hard, friable; many fine roots; slightly acid; gradual smooth boundary. (0 to 8 inches thick)

Bt--15 to 35 inches; dark grayish brown (10YR 4/2) sandy clay, grayish brown (10YR 5/2) dry; common medium distinct yellowish red (5YR 5/6) and few fine distinct yellowish brown redoximorphic accumulations; weak coarse prismatic structure that parts to moderate medium blocky structure; very hard, very firm; few fine roots; nearly continuous clay films on faces of peds; neutral; gradual smooth boundary. (14 to 29 inches thick)

BCt--35 to 45 inches; dark grayish brown (10YR 4/2) sandy clay loam, grayish brown (10YR 5/2) dry; many medium distinct yellowish red (5YR 5/6) and few fine distinct yellowish brown redoximorphic accumulations; weak coarse prismatic structure that parts to weak fine and medium blocky structure; very hard, very firm; discontinous clay films on faces of peds; few fine calcium carbonate concretions; slightly effervescent; moderately alkaline; gradual smooth boundary. (8 to 15 inches thick)

C--45 to 60 inches; brown (10YR 5/3) fine sandy loam, pale brown (10YR 6/3) dry; common medium distinct yellowish red (5YR 5/6) and few fine distinct yellowish brown redoximorphic accumulations; massive; hard, friable; few fine calcium carbonate concretions; calcareous, moderately alkaline.

Appendix VII. Frenchtown series profile description.

FRENCHTOWN SERIES
The Frenchtown series consists of very deep, poorly drained soils formed in loamy Wisconsinan age till on till plains. Some pedons have a thin mantle of loess. Permeability is moderate above the fragipan and slow or very slow in the fragipan. Slope ranges from 0 to 8 percent. Mean annual precipitation is about 35 inches, and mean annual temperature is about 50 degrees F. **TAXONOMIC CLASS:** Fine-loamy, mixed, active, mesic Typic Fragiaqualfs **TYPICAL PEDON:** Frenchtown silt loam, on a nearly level area reverting to brush and trees, formerly a cultivated field. (Colors are for moist soil unless otherwise noted.)

Ap-- 0 to 7 inches; grayish brown (10YR 5/2) silt loam, light brownish gray (10YR 6/2) dry; moderate medium and coarse granular structure; friable; few fine black (10YR 2/1) concretions (iron and manganese oxides); very strongly acid; abrupt smooth boundary. (6 to 10 inches thick.)

Beg-- 7 to 12 inches; light brownish gray (2.5Y 6/2) silt loam; moderate medium subangular blocky structure; firm; common medium black (10YR 2/1) concretions (iron and manganese oxides); few rock fragments; many medium distinct yellowish brown (10YR 5/6 and 5/8) masses of iron accumulation in the matrix; very strongly acid; clear wavy boundary. (0 to 10 inches.)

Btg1-- 12 to 21 inches; light brownish gray (2.5Y 6/2) silty clay loam; moderate medium subangular blocky structure; firm; few faint clay films on sides of pores; many faint light brownish gray (2.5Y 6/2) clay depletions on faces of peds; 2 percent rock fragments; many medium distinct yellowish brown (10YR 5/6 and 5/8) masses of iron accumulation in the matrix; very strongly acid; clear wavy boundary.

Btg2-- 21 to 30 inches; gray (5Y 5/1) silty clay loam; moderate medium subangular blocky structure; firm; common faint clay films on faces of peds; gray (5Y 6/1) clay depletions on faces of peds; few medium black (10YR 2/1) concretions (iron and manganese oxides); 2 percent rock fragments; very strongly acid; clear wavy boundary. (Combined thickness of the Btg horizons is 3 to 20 inches.)

Btx1-- 30 to 41 inches; dark yellowish brown (10YR 4/4) clay loam; weak very coarse prismatic structure parting to weak thick platy; polygons are 4 to 5 inches across; very firm; many distinct clay films on vertical faces of peds; common faint clay films on some horizontal surfaces; many prominent gray (5Y 6/1) clay depletions on faces of peds; common very dark brown (10YR 2/2) soft accumulations (iron and manganese oxides) in ped interiors; 5 percent rock fragments; 60 percent brittle; strongly acid; clear smooth boundary.

Btx2-- 41 to 48 inches; brown (10YR 4/3) loam; weak very coarse prismatic structure; very firm; few faint clay films on some horizontal surfaces; many prominent gray (5Y 6/1) clay depletions on vertical faces of peds; 5 percent rock fragments; 60 percent brittle; strongly acid; gradual smooth boundary. (Combined thickness of the Btx horizons is 11 to 40 inches.)

BC1-- 48 to 57 inches; brown (10YR 4/3) loam; weak very coarse prismatic structure; firm; few prominent gray (5Y 6/1) coatings on prisms; 10 percent rock fragments; very strongly acid; clear smooth boundary.

BC2-- 57 to 66 inches; yellowish brown (10YR 5/4) clay loam; weak very coarse prismatic structure; firm; few prominent gray (5Y 6/1) coatings on prisms; 10 percent rock fragments; moderately acid; clear smooth boundary. (Combined thickness of the BC horizons is 0 to 24 inches.)

C-- 66 to 80 inches; yellowish brown (10YR 5/4) loam; massive; firm; 12 percent rock fragments; moderately acid.

DRAINAGE AND PERMEABILITY: Poorly drained. The potential for surface runoff is negligible to medium. Permeability is moderate above the fragipan and slow or very slow in the fragipan. In undisturbed areas the depth to an intermittent perched seasonal high water table ranges from 1 foot above the surface to 0.5 foot below the surface from October to May in normal years.

USE AND VEGETATION: Principal uses are cropland, former cropland reverting to forest, forest, and pasture in approximately equal amounts. Where adequately drained, the principal crops include corn, wheat, or oats and meadow. The natural vegetation is elm, ash, red maple, swamp white oak, and pin oak.

National Cooperative Soil Survey
U.S.A.

Oklahoma State University Institutional Review Board

Date:	Monday, September 21, 2009
IRB Application No	AG0933
Proposal Title:	Erosion Simulators as a Teaching and Motivational Tool
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 9/20/2010

Principal Investigator(s):

Laura Eskridge	Jeff Hattey
165 Ag Hall	170 Ag Hall
Stillwater, OK 74078	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

[X] The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

Oklahoma State University Institutional Review Board

Date	Tuesday, February 09, 2010	Protocol Expires:	9/20/2010
IRB Application	AG0933		
Proposal Title:	Methods for Teaching Soil Conservation in the College Setting		

Reviewed and Processed as: Exempt

Modification

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s) :

Laura Eskridge	Jeff Hattey
165 Ag Hall	170 Ag Hall
Stillwater, OK 74078	Stillwater, OK 74078

The requested modification to this IRB protocol has been approved. Please note that the original expiration date of the protocol has not changed. The IRB office MUST be notified in writing when a project is complete. All approved projects are subject to monitoring by the IRB

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

Signature :

Sheila Kennison, Chair, OSU Institutional Review Board

Tuesday, February 09, 2010
Date

VITA

Laura Marie Eskridge

Candidate for the Degree of Plant and Soil Science

Master of Science

Thesis: TEACHING SOIL CONSERVATION IN AN INTRODUCTORY SOIL SCIENCE LABORAROTY AND THE CLASSIFICATION OF EXAMINATIONS USING THE REVISED BLOOM'S TAXONOMY

Major Field: Plant and Soil Science

Biographical:

Personal Data: Born in Edmond, Oklahoma on September 19th, 1985, daughter of Evelyn and Walter Eskridge.

Education:

Completed the requirements for the Master of Science Degree in Plant and Soil Science at Oklahoma State University, Stillwater, Oklahoma in December, 2010.

Completed the requirements for the Bachelor of Science Degree in Botany at Oklahoma State University, Stillwater, Oklahoma in May, 2008.

Experience:

From August 2008 to July 2010: Teaching Assistant, Plant and Soil Science Department, Oklahoma State University; Responsibilities: Teaching laboratory sections, Training teaching assistants, Designing curriculum, Substitute Lecturing, Conducting review sessions, Managing classroom and laboratory materials.

From September 2007 to August 2008: Lab Technician, Botany Department, Oklahoma State University; Responsibilities: Performing PCR and DNA extraction, Indentifying plants in the field, Creating, measuring, and recording data for vegetation plots.

From May 2007 to July 2007: Fire Effects Intern, Lake Meredith National Recreation Area, Borger, Texas; Responsibilities: Creating, measuring, and recording data for vegetation plots, Controlled burning.

From February 2007 to May 2007: Greenhouse Assistant, Plant and Soil Science Department, Oklahoma State University; Emasculating and pollinating wheat plants, Watering and maintaining wheat plants.

Name: Laura Marie Eskridge Date of Degree: December, 2010

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: TEACHING SOIL CONSERVATION IN AN INTRODUCTORY SOIL SCIENCE LABORAROTY AND THE CLASSIFICATION OF EXAMINATIONS USING THE REVISED BLOOM'S TAXONOMY

Pages in Study: 99 Candidate for the Degree of Master of Science

Major Field: Plant and Soil Science

Chapter I Scope and Method of Study: Within soil science literature, there are adequate examples of soil conservation lesson plans; however, the majority have not been empirically tested to validate their efficacy. The objective of this study was to determine the effectiveness of two soil conservation teaching methods. Data was collected over two semesters with procedural changes occurring in the second semester. For the Simulator Group, students took a field trip to use a rainfall simulator and wind tunnel and completed post-lab questions and calculations. The Lecture Group was a combination of lecture and small group activities in the classroom, which were also followed by calculations and questions. Students completed a pre-test, two post quizzes, and an opinion survey. A second survey was added during the second semester for students to state a preference for either group after participating in both.

Chapter I Findings and Conclusions: There were no significant differences between groups for pre-test scores, quiz scores, or quiz score retention. On survey one, students who participated in the lecture method indicated that they learned more than students who went on the field trip. However, on the second survey, students showed a preference for the Simulator Group in eight out of sixteen categories with no significant preferences for the Lecture Group.

Chapter II Scope and Method of Study: Bloom's Taxonomy has been used for over fifty years to classify exams and learning objectives in an effort to improve the cognitive level of curriculum. A revision of Bloom's Taxonomy was published in 2001 which separated the original taxonomy into the cognitive domain and knowledge dimension. The goal of this study was to determine if there was a difference between soil science exams in taxonomic level for the Revised Bloom's Taxonomy, cognitive domain, or knowledge dimension classifications.

Chapter II Findings and Conclusions: Across Exam Year, classifications Analyze and Analyze-Conceptual increased. There were no significant differences between semesters and few differences between varying numbers of exams between semesters. However, there were a large number of imbalances in classification between exam numbers within semesters.

ADVISER'S APPROVAL: Dr. Jeff Hattey