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Assessing the Degree of Integrated Learner-Centered Instruction on Student Outcomes in a Large Non-Major Environmental Science Course

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Keywords
College teaching, Integrated learner-centered instruction, Large lecture courses

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Introduction

Since the mid-1930s, there has been a wealth of discourse concerning the use of learner-centered and teacher-centered methodologies in K-16 learning environments (Angelo, 1997; Barr & Tagg, 1995; Berquist & Phillips, 1975; Bland *et al*., 2007; Burgan, 2006; Johnstone & Percival, 1976; Knight & Wood, 2005; Lord, 1997; Richardson, 2008). Often, the two have been sharply contrasted with proponents found on one side of the debate or the other. Advocates of teacher-centered methods such as the lecture, have proffered positive effects of excellent lectures. Authors such as Burgan (2006), Bland *et al*., (2007) and McKeachie and Svinicki (2006), posit that lectures conducted by exceptional lecturers can be very beneficial as they are able to:

- Provide up-to-date information on current research in the field of study;
- Weave together and summarize related information from a variety of sources, personal observations and research;
- Model problem solving approaches and techniques; and
- Engage and motivate students to learn by imbuing their own passion for the subject.

In contrast, however, opponents of the lecture method site some less than positive effects of the lecture including:

- Often serves as a one-way mode of communication;
- Encourages student passivity and student use of lower-order cognitive skills (LOCS)(Zoller, 1993) such as rote memorization;
- Promotes poor attention and retention;
- Fails to engage students intellectually.
  (Bligh, 2000; Bland *et al*., 2007; Kozma *et al*., 1978; Powell, 2003; Smith *et al*., 2005; Crowe *et al*., 2008)

On the other side, proponents of learner-centered methods such as inquiry-based learning in which connections are made between prior knowledge and scientific descriptions of the natural world (Panasan & Nuangchalerm, 2010); and problem-based or case-based learning which, is the fundamental process of integrating basic science and clinical information (DiLullo *et al.*, 2009) have also proffered positive effects. Authors such as Cornelius-White, 2010; Ebert-May *et al*., 2008; Freeman *et al*., 2007; Felder & Brent, 1996; Hake, 1998; Handelsman, 2004 & 2007, Knight & Wood, 2005; McKeachie, 1972; Prince & Felder, 2006; and Udovic *et al*., 2002, posit that learner-centered methods can be very beneficial as they are able to:

- Actively engage students and encourages student use of higher-order cognitive skills (HOCS) (Zoller, 1993) in the subject of study;
- Improve students' writing, thinking and problem-solving skills;
- Increase students' retention of material; and
- Motivate students to apply their learning.

Yet opponents, along with more than a few advocates, of learner-centered methods also cite the fact that:

- The methods themselves often do not translate into significantly improved learning outcomes (Prince, 2004);
- Students find comfort in teacher driven lectures (Felder & Brent, 1996); and
- Students often show resistance to learner-centered methods (McKeachie, 1972; Sorcinelli, 1991).

As a case in point, in a more recent study, (Walker *et al*. 2008) teacher-centered methods were again juxtaposed against learner-centered methods in a large introductory Biology classroom at an equally large Minnesota university. Teacher-centered methods consisted of lecture, unannounced quizzes, and multiple choice exams. In contrast, the learner-centered section consisted of shortened lectures, ungraded group activities, unannounced quizzes,

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graded homework assignments, and multiple-choice exams. As with previous studies, the results demonstrated only a small difference between the mean final percentage scores in the direction of the learner-centered method (p.363). Additionally, as was found with other studies, when the students were asked to evaluate the course and their instructors, the scores were significantly higher in favor of the teacher-centered lecture section versus the learner-centered section (p. 364). So, instead of asking "which method is better, teacher-centered versus learner-centered," maybe the question should be "can integrating learner-centered methods into large lecture sections increase student scores?" Again, according to a variety of studies, the answer to this question also appears to be yes (Ebert-May, Brewer, & Allred, 1997; Huba & Freed, 2000; Allen & White, 2001; Donham, Schmieg, & Allen, 2001; Smith, Stewart, Shields, Hayes-Klosteridis, Robinson, & Yuan, 2005; Knight & Wood, 2006). Yet, like both teacher-centered and learner-centered methods, the integrated method also comes with an inherent set of issues.

One issue currently receiving a great deal of attention is the lack of reliable tools that can effectively assess students' use of higher-order cognitive skills (HOCs) (Crowe *et al*., 2008). But another key issue also in need of attention centers on the amount or degree of integrated learner-centered instruction provided in the large lecture classroom. According to Allen and Tanner (2005), the most commonly used integrated techniques include asking questions during lecture, using classroom technology for immediate feedback, allowing students the opportunity to conduct projects and present their work, problem-based learning, case studies, peer-led team learning, and modeling inquiry. But each of these techniques varies in the degree of learner-centeredness allowed. In the first instance, asking questions during lecture, allows for a minimal degree of learner-centered instruction leaving the bulk of instruction still to be delivered by lecture. In contrast, problem-based learning and case studies rely much more heavily on the learner, significantly minimizing lecture, and thus allowing for a higher degree of learner-centered instruction.

Based on the research concerning teacher-centered, learner-centered and integrated learner-centered instruction, student evaluations of learner-centered instruction, and the recognition that the degree of learner-centered instruction proffered, varies. We wanted to explore whether significant differences in test and/or semester scores would be evidenced between two groups who were provided with contrasting degrees of learner-centered instruction. Student success was measured via a pre-test/post-test, online assignments, in-class assignments and end of course scores.

Methods and Materials

Purpose and Research Questions

The purpose of this study was to assess the effects (as measured by student scores and course evaluations) of utilizing varying degrees of learner-centered instruction in a large lecture undergraduate non-major environmental science course. The guiding research questions were:

1. Will students who answer post-test questions in four unit exams given during the semester score higher than students who answer post-test questions in a comprehensive final exam?
2. Will students who receive a minimal degree of integrated learner-centered instruction (MLC) achieve higher semester scores than students who receive a higher degree of integrated learner-centered instruction (HLC)?

3. Will students be less receptive to the integration of a higher degree of learner-centered (HLC) instruction into the large lecture classroom than students receiving a minimal degree of learner-centered instruction (MLC)?

Context

The course used in this study, Environmental Science, is a 3-hour non-science major elective course. The study was conducted at a large Texas public institution with more than 28,000 undergraduate students enrolled as of fall 2009. Since the inception of the course, environmental science has been taught in a traditional teacher-centered, large-lecture format, consisting of 1.5 hour Power Point™ based lectures delivered by science faculty twice per week. Along with most other large universities, however, in recent years we as faculty have been tasked with heeding the call to re-envision our large lecture courses so that they emphasize applications and connections and encourage student involvement and active participation in their own learning (American Association for the Advancement of Science, 1990; Boyer Commission on Education Undergraduates in the Research University, 1998; Cheney, 1989; Ebert-May *et al*. 1997; Hazen & Trefil, 1991; National Research Council, 1996b, 1997, 1999a, 1999b, 2002a, 2003b; National Science Foundation, 1999; Project Kaleidoscope, 2002; Smith *et al*., 2009; Springer *et al*., 1999; Sundberg *et al*. 1994; Umbach *et al*., 2005; and Wilson, 1986). Thus, using the research on most effective strategies (teacher-centered, learner-centered and integrated) for large lecture science classrooms as our platform, we developed two large lecture environmental science sections, each taught with a different degree of integrated learner-centered instruction to determine if there would be a measurable effect on student outcomes.

Sample

Students

Two classes or sections were used in this study; one group received minimal integrated learner-centered (MLC) instruction (<5%) and another group received a higher degree of integrated learner-centered (HLC) instruction (>75%). The MLC consisted of 211 students. The HLC consisted of 82 students. Both groups were comprised of students who ranged, academically, from first semester freshman to final semester seniors. The course schedule did not denote any differences between the two sections. Section one was listed as ENV 1132.001, TR 12:30-1:50 pm and section two was listed as ENV 1132.002 TR 4:00-5:20 pm. Thus students were not assigned to either the MLC or HLC group but rather self selected the course section that best fit their scheduling needs. In addition, all 293 students participated in a pre-test and no significant difference (Pearson product moment correlation, $p=0.12$) was found when comparing the results between the two groups.

Professors

The minimal degree of integrated learner-centered instruction section (MLC) was taught by a distinguished teaching and research professor with 24 years teaching experience at the collegiate level and historically high student evaluation ratings. The higher degree of integrated learner-centered instruction section (HLC) was taught by a tenure-track assistant teaching and research professor who has more than 20 years of teaching experience, 10 of which are at the collegiate level, and equivalent student evaluation ratings.

Structure

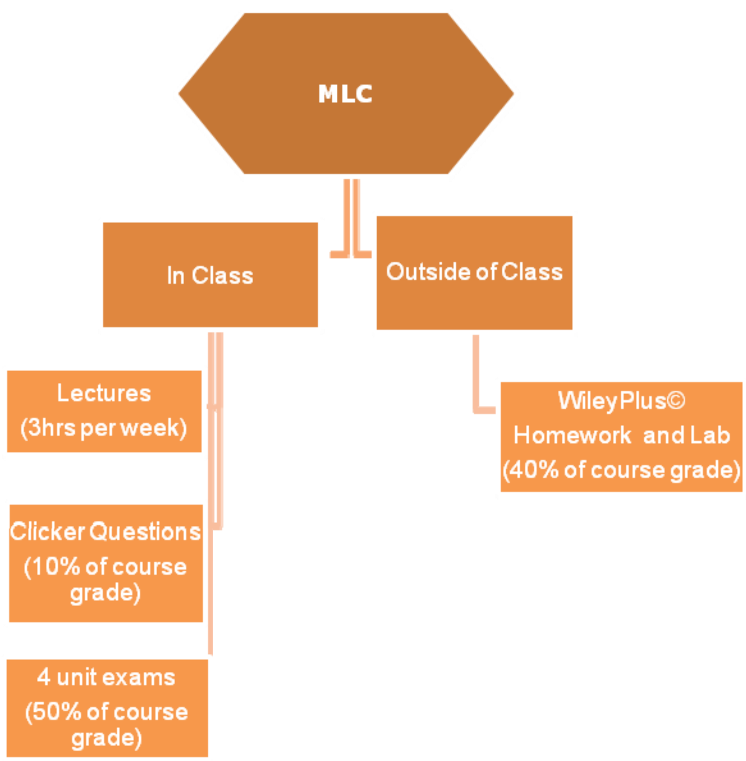
To begin the semester, both professors required students to take an online pre-test. This test was comprised of 146 multiple-choice questions and students were given a 2-hour window in which to complete it. We chose multiple-choice testing because it has been demonstrated as an efficient method to assess the depth and breadth of students' knowledge while not putting those with weak reading skills at a disadvantage (Epstein *et al*, 2002; Veeravagu *et al*, 2010). The results of the pre-test demonstrated that there was not a significant difference between the two groups (p=0.12) as of the first day of class. Additionally, both professors provided 3 office hours per week and had teaching assistants who served as proctor/graders for 1-3 hours per week as needed.

The requirements held constant for both MLC and HLC groups included:

- course text, *Visualizing Environmental Science* by Berg and Hager, 2009;
- course outline
- instruction around five concepts: nature of science; evolution and ecosystems; pollution; resources; and action;
- use of Clickers™ in the classroom
- student participation in laboratories and bi-weekly online homework assignments; and
- a large lecture hall with fixed seating for 230 students.

In addition to the above, the MLC group was provided with 1.5 hours of notes-based lectures twice per week for 16 weeks (see Figure 1). The minimal learner-centered method used consisted of technology based Clicker™ questions proffered randomly throughout lectures. According to Zoller (1993), this type of lecture-oriented teaching methodology only engages students' low-order cognitive skills (LOCS). Tests were graded by a proctor/grader and scores were posted on Blackboard Vista©.

Figure 1. Course Sections with Grade % Breakdown



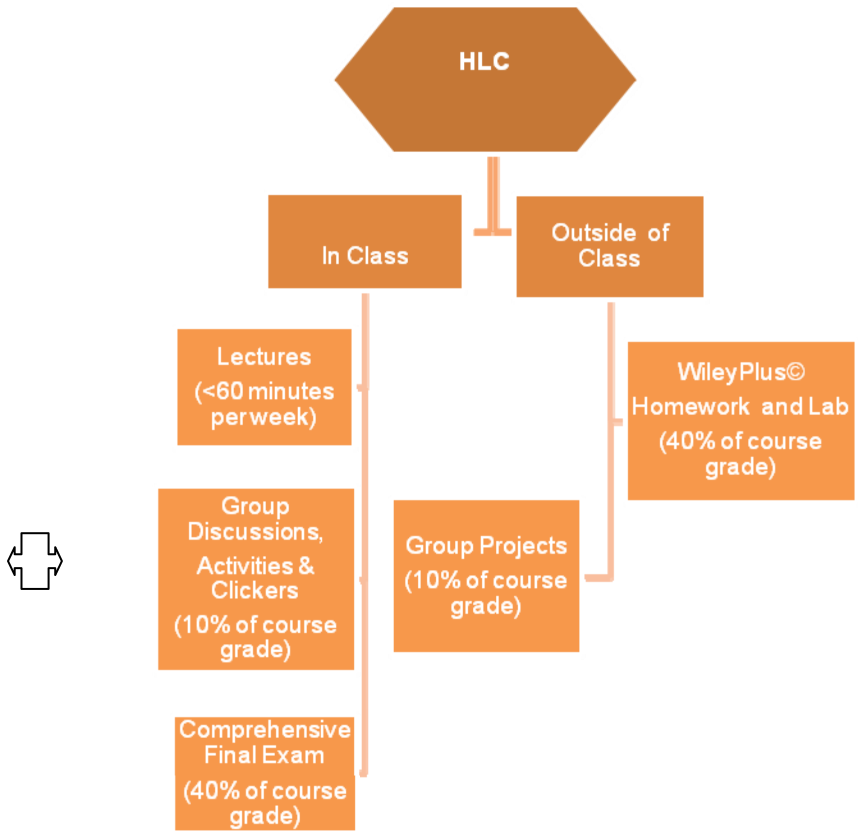


Figure 1. comparison of grading criteria between MLC and HLC class sections.

In addition to the constants listed above, the HLC group was provided with 30 minutes or less of lecture twice per week for 16 weeks; structured graded in-class group activities; four graded problem-based group projects/presentations; and an individual 6-week case study (see Figure 1). Tests were graded by a proctor/grader; group projects were either peer-graded and/or graded by the instructor; and written feedback was provided for each group project and the individual 6-week case study.

HLC Activities

In-class activities conducted throughout the semester were integrated with the lecture in order to support or highlight specific key concepts being taught. In-class activities included individual clicker questions, game-like activities where student groups experienced and worked together to solve specific environmental problems, and time for group work on projects/presentations. All activities were designed to actively engage students in quantitative and qualitative conceptual questions which were previously unfamiliar to the students. According to Zoller & Tsaparlis (1997) these types of activities engage students' higher-order cognitive skills (HOCS) as they require the student to apply the abilities of reasoning, decision-making, analysis, synthesis and critical thinking. The HLC activities were designed based on the work of Ebert-May and Hodder (2008). Assessments were premised on the work of Crowe, Dirks and Wenderoth (2008) who, in turn, use Bloom's Taxonomy of cognitive domains (Bloom *et al*., 1956) as their foundation. Rubrics were provided to outline professor expectations for each activity assigned (see appendix B-D). The graded group HLC activities included:

1. The Nature of Science – Bloom's *Analysis*
   Activity: Scientific evidence. Students were provided with a research article on the topic being discussed in lecture. The students were asked to work in their groups inside and outside of class to discover and identify the steps of the scientific method found within the article. Students submitted a written report of their findings (Appendix B).

2. Resources – Bloom's *Synthesis*
   Activity: Conceptualizing evidence. Groups were assigned a harmful chemical found in the environment and were tasked with making a brochure that outlined the potential risks associated with that chemical. Students submitted group brochure for grading (Appendix C).

3. Action – Bloom's *Synthesis*
   Activity: The individual six-week project was to drive their car one day less per week. Students were asked to provide details about their car, or their imaginary car if they didn't own one and driving habits in their blog space on Blackboard Vista©. Students were to blog weekly about their experience and for their final report they were to recount their six-week, including their analysis of carbon-offset, findings in a minimum 3-page report (Appendix D).

4. Evolution and Ecosystems - Bloom's *Evaluation*
   Activity: Comparing evidence. Groups were provided the opportunity to select sides of an issue, work as a team in and outside of class to hone their side and then work as a team in class to debate their group's point of view. Students received peer-evaluations on their presentations.

5. Pollution – Bloom's *Evaluation*
   Activity: Interpreting evidence. Groups were provided with a research article on the topic being discussed in lecture. The students were tasked with creating a structural model (at least two graphs), which described a pattern or data-based relationship they were able to extract from the article. Students submitted their models for grading.

Measures
The measure for our first question, "Will students who answer post-test questions in four unit exams given during the semester score higher than students who answer post-test questions in a final comprehensive exam?" consisted of pre-test/post-test assessments. The pre-test was drawn from a test bank which was derived directly from the learning objectives set forth by the course text, *Visualizing Environmental Science* (Berg & Hager, 2009). Through Wiley Inc., learning objectives for each chapter were given to a panel of Subject Matter Experts (SMEs) who were tasked with developing measurable assessments for each content module based on Bloom's Taxonomy (Bloom *et al*., 1956). This information was issued through proprietary documents released by Wiley Inc., the text-book publisher, and served as a guideline for the SMEs associated with the text materials. All text-book materials were thoroughly reviewed and edited by SMEs, faculty and students (Berg & Hager, 2009).

To establish a baseline for comparison between the pre-test and post-test scores, the pre-test scores were analyzed. The results demonstrated that of the original 146 pre-test questions, all 293 participants missed 37 questions. Thus questions excluded from the study were those questions that received the highest percentage of correct answers as evidenced by the pre-test. Both professors agreed that the material for the 37 missed questions would be taught via MLC or HLC methods. For the MLC section the material from which the 37

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questions were drawn would be taught via lecture and Clickers™. For the HLC section the material from which the 37 missed questions were drawn would be taught via problem and project based learner-centered methods. The MLC group would participate in four multiple-choice unit exams during the semester. The multiple choice questions would include those from the pre-test and the 37 missed questions would be post-tested throughout and within the four unit exams. In contrast, the HLC group would participate in a comprehensive multiple choice final exam (Appendix A). The multiple choice questions would be taken from the pre-test and would include the original 37 missed questions. In order to account for the uneven distribution of students per course section, each correct answer out of the 37 selected multiple-choice questions would be divided by the number of students in each class section. All analyses were run on percentages of correct answers per each of the 37 identified questions. In addition, all data was tested for normality of distributions (Shapiro-Wilks test for normality) before specific statistical analyses were performed. Content validity, as described by Salkind (2004), was confirmed via subject matter experts (SMEs) associated with the text book materials (Berg & Hager, 2009). A test re-test reliability was conducted via a Pearson product moment correlation, and measures of central tendency as well as an independent t-test were used to determine statistical significance at the 0.05 level. All statistical analyses were conducted using SigmaStat 3.5 and SigmaPlot 10.0.

In addition, Bloom's taxonomy (Bloom *et al*., 1956) categories were used to separate the 37 multiple-choice questions into the hierarchical groups of Knowledge, Comprehension, and Application (Figure 3). For the purpose of this study, we defined *knowledge* as the ability to recall previously known material; c*omprehension*, as the ability to grasp the meaning of material; and *application*, as the ability to use learned material in new concrete situations (Alcázar & Fitzgerald, 2005; Bloom, 1956). A two-way parametric ANOVA was used to test whether there was an interaction between Bloom's category and degree of integrated learner-centered instruction. Student-Newman Keuls (SNK) multiple range *post hoc* tests were run to separate data into distinct groups and an interrater reliability test was used to determine the consistency of the raters on aligning the test questions with Bloom's categories (see Appendix A for test questions). Upon analysis of the missed questions we determined that all 37 were attributable to the lower end of Bloom's scale. Thus the post-test would only be viable for measuring the LOCS of both the MLC and the HLC groups.

To measure our second question, "Will students who receive a minimal degree of integrated learner-centered instruction (MLC) achieve higher semester scores than students who receive a higher degree of integrated learner-centered instruction (HLC)?" we used rubrics to measure and confer scores on student work in the HLC group. The MLC group did not participate in HLC activities and thus we would not be able to directly compare any HOCS scores between the two groups. However, comparing the end of course scores of the two groups would allow us to determine if there were significant overall grade differences evidenced between the HLC and MLC groups.

Student Evaluation of Teaching Effectiveness (SETE) scores were used to measure our third question. At this university SETE scores are a measure of student perception of teaching effectiveness. All individual scores are on the same scale so that a score of, say 600, for a teacher of a particular course in a particular department or college has the same meaning in terms of teaching effectiveness as a teacher of a course in a different department or college. To help with score interpretation, the following factor descriptions of effectiveness are provided per the University's Institutional Research and Effectiveness board:

Factor 1: Organization and Explanation of Materials (OEM)

This score reflects the student's perception of how well the instructor: makes the course requirements and student learning outcomes clear to the students; gives assignments, activities and materials that are helpful and that contribute to understanding the subject; explains difficult material clearly; shows the relationships among topics and new concepts; and evaluates student work in ways that are helpful to learning.

Factor 2: Learning Environment (LE)
This score represents the student's perception of how well the instructor establishes a climate of mutual respect and encouragement; motivates students to work and engage in learning; is available and encouraging; is skillful in actively engaging students in learning; and provides useful feedback.

Factor 3: Self-Regulated Learning (SRL)
This score represents the student's perception of how well the instructor guides and encourages self-directed learning in which the student is encouraged to: be open to the viewpoints of others; develop new viewpoints; connect course topics to a wider understanding of the subject; and contribute to the learning process.

To give meaning to the scores in terms of a scale of teaching effectiveness, the board established cut points to identify a range of effectiveness (Table 1). Three levels were established and the scale score range for each level is as follows:

Table 1. SETE Scale Score Ranges for Effectiveness Levels by Factors

Effectiveness	OEM	LE	SRL	Overall
Highly Effective	710 - 981	659 – 972	747 - 998	701 - 998
Effective	438 - 709	347 – 658	495 - 746	406 - 701
Somewhat Effective	167 - 437	35 – 346	243 - 494	111 - 405

Results

The most straightforward answer to our first question, "Will students who answer post-test questions in four unit exams given during the semester score higher than students who answer post-test questions in a comprehensive final exam?" is no. The MLC class of students who answered the post-test questions in four unit exams did *not* score higher than the HLC class of students who answered the post-test questions in a comprehensive final exam. In analyzing the percentage of correct answers per question given by each student across the two groups, independent of test method, data confirmed that there was not a statistically significant difference found between the MLC class taking the four unit tests and the HLC class taking the comprehensive final exam as measured by the pre-test versus post-test scores (Independent t-test, $p=0.857$). On average, 79% ± 2.2% of the HLC students taking the comprehensive final exam gave correct answers on the post-test. For the MLC students taking the four unit tests an average of 79% ± 2.4% of students gave correct answers (Table 2; Figure 2). In addition, we also compared percentage of correct answers per question across both Bloom's Taxonomy category and test method (Table 3; Figure 4). Again, there was not a statistically significant difference found among Bloom's categories, test method, or the interaction of the two (Two-Way ANOVA, $p=0.987$, $p=0.631$, $p=0.796$, respectively). On average, 79% ± 3.5% and 78% ± 4.5% of the HLC students taking the comprehensive exam gave a correct answer on the knowledge and

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comprehension based questions, compared to 79% ± 3.7% and 79% ± 4.0% of students from the MLC group taking the four unit tests.

Table 2. Percent Correct Answer by Method

Method	RANGE	MEAN	MEDIAN
MLC (211)	35% - 98%	79%	82%
HLC (82)	43% - 96%	79%	80%

Figure 2. Comparison of Correct Answers per Group Accounting for Method

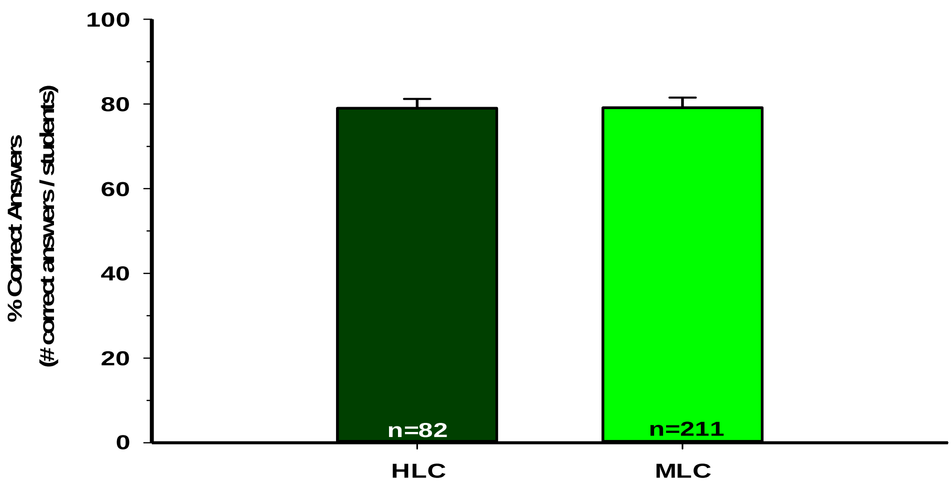

Figure 2*:* The percent of correct answers for 37 total questions (n=37), compared across the teaching method (Independent t-test, p=0.86); Mean ± SE; α=0.05.

Figure 3. Bloom's Taxonomy

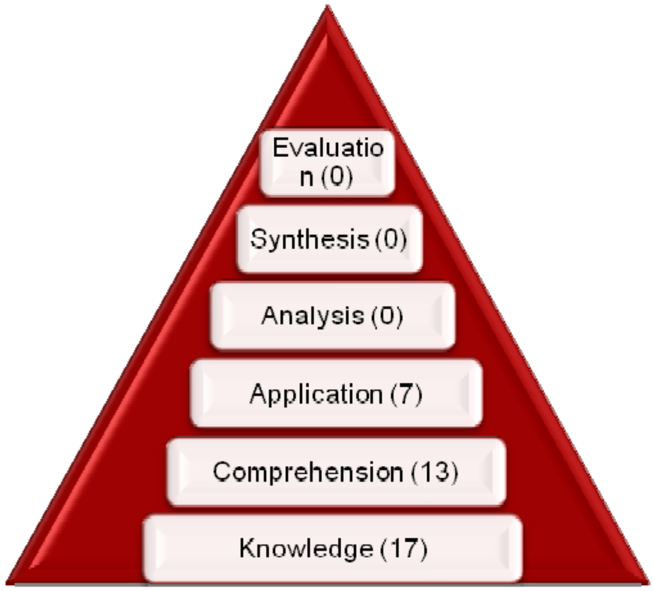

Figure 3: Bloom's Taxonomy of educational objectives; number of questions for each objective shown (). Interrater reliability = .948.

Table 3. Percent Correct Answer by Method and Bloom's Taxonomy

Bloom's	Group	RANGE	MEAN	MEDIAN
KNOWLEDGE (17)	MLC	51% - 98%	79%	82%
	HLC	51% - 96%	79%	85%
COMPREHENSION (13)	MLC	43% - 97%	79%	80%
	HLC	43% - 96%	78%	84%
APPLICATION (7)	MLC	35% - 91%	78%	88%
	HLC	67% - 95%	82%	80%

Figure 4. Comparison of Answers Missed per Group and Bloom's Taxonomy

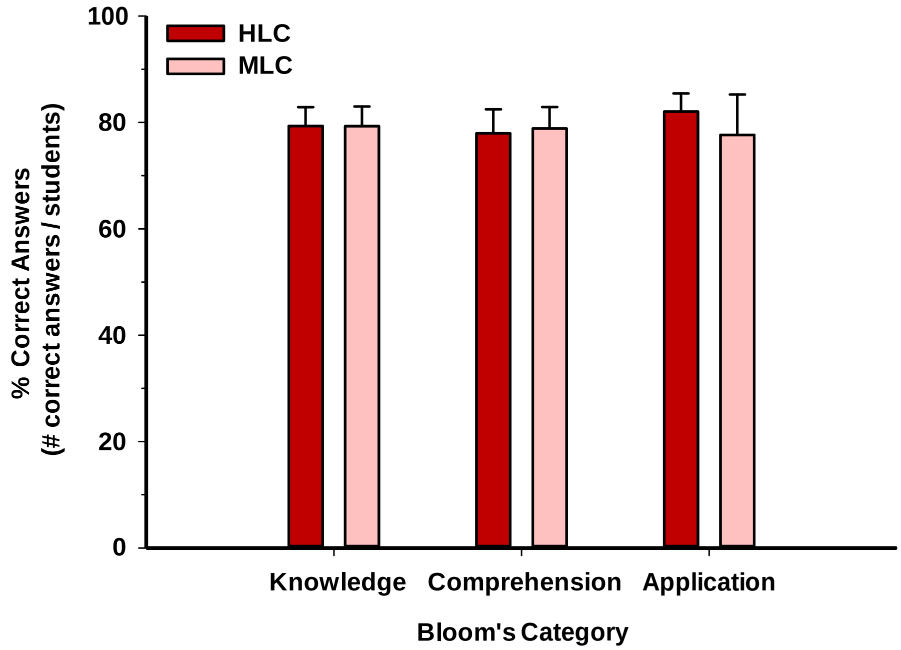

Figure 4: The percent of correct answers for 37 total questions (n=37), compared across teaching method, Bloom's Taxonomy category, and the interaction between the two (Two-Way ANOVA, p=0.99, p=0.63, p=0.80, respectively); Mean ± SE; α=0.05.

The data for our second question also showed that there was not a statistically significant difference in the end-of-course grades between the HLC and MLC groups (Table 4; Figure 5). Though the grading criteria were appreciably different between the class sections (Figure 1), the results demonstrated that even though the HLC group was provided with opportunities to apply the more challenging HOCS, their end of course scores were statistically comparable to the MLC group who were not challenged with applying HOCS.

Table 4. Fall 2009 Final Grades

Method	RANGE	MEAN	MEDIAN
MLC (211)	50 – 99	82	83
HLC (82)	40 – 100	83	84

Figure 5. 2009 Final Grade Averages for HLC and MLC Groups

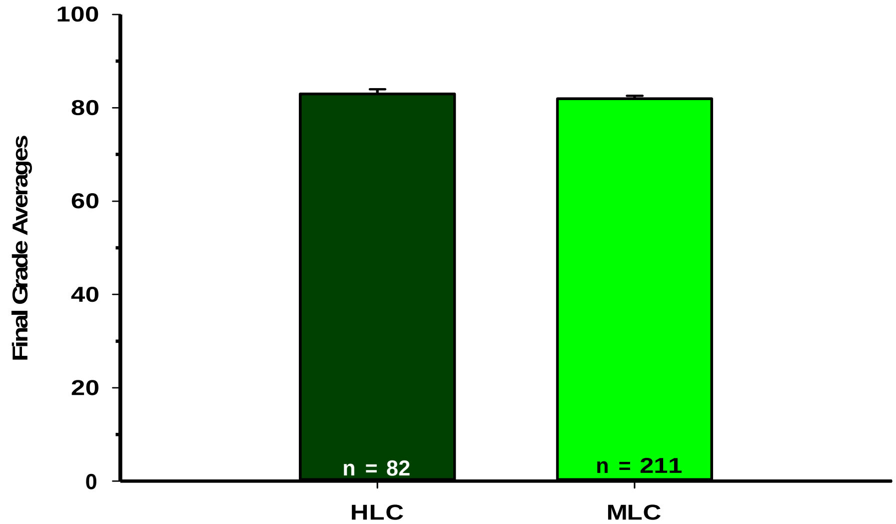

Figure 5: Final grade averages compared between sections for Fall 2009 semester (Independent t-test, p=0.74); Mean ± SE; α=0.05.

To address our third research question, "Will students be less receptive to the integration of a higher degree of learner-centered (HLC) instruction into the large lecture classroom than students receiving a minimal degree of learner-centered instruction (MLC)?" we compared the end-of-semester SETE scores for the two sections. The essentially equivalent LE scores (Table 5), demonstrate that the students perceived both classrooms to have an equal climate of mutual respect and encouragement; and that each professor equally motivated the students to work and engage in learning. Though both sections received equivalent scores overall, Highly Effective range on the SETE Scale (See Table 1), the higher score for the HLC section on the SRL effectively demonstrates that the students perceived that they were credibly guided and encouraged in their self-directed learning above what was noted for the MLC section. We see this as a positive indication of students' increasing willingness to assume additional responsibility for their own in class learning.

Table 5. Instructor SETE Scores for sections used in this Study

Method	OEM	LE	SRL	Overall
MLC (126)	815	792	800	802
HLC (59)	795	793	818	802

Discussion

At first glance, with no statistical significance found between measures of the two groups, it may appear that this study does not advance the integrated learner-centered discussion. However, it may well be the fact that there were not statistical differences found that make these results meaningful.

Pre-test/Post-test

Initially we had hypothesized that the MLC students who took the four unit tests (one test per four weeks) would score higher than the HLC students taking the comprehensive final due to the fact that the unit tests were given closer to the learning of the material. In addition, since the MLC students spent the preponderance of their class time involved in LOCS, which is mainly what this multiple-choice test examined, we believed they would achieve higher scores than the HLC students who spent their class time progressively engaged in all six of Bloom's categories (LOCS and HOCS). Yet, in truth, the HLC students achieved comparable post-test scores though they were tasked with retaining the material for the entire 16-weeks. So, though the post-test scores were not significantly different between the two groups, it may well be that the HLC students did learn more than the MLC students due to the fact that comprehensive or end-of-course exams require greater retention of knowledge (Bishop *et al*., 2001). In addition, it is also interesting to note that for the seven "application" post-test questions (see Appendix A), a mean difference of 4% was evidenced with the HLC class on the comprehensive exam over the MLC class on the four unit tests. This may be suggestive of a correlation between students having the opportunity to apply their HOCS through the HLC activities and their ability to answer application questions in an exam setting. However because the two groups were tested differently, a follow-up study which tasks both MLC and HLC students with taking a comprehensive final exam is needed to ascertain whether or not HLC activities are contributing factors to long-term retention of LOCS.

End-of-course scores

For our second question we had assumed that the MLC students would earn higher end-of-course scores considering they were tasked with applying LOCS and were only assessed through multiple-choice questions. The HLC students however, in addition to the LOCS were also tasked with applying HOCS, which were measured with constructed-response questions (see appendix B-D). Constructed-response questions differ from multiple-choice questions in their scoring objectivity and the fact that constructed-response questions are open-ended versus multiple-choice questions which provide fixed answers (Rodriguez, 1993; Scouller & Prosse, 1994; Scouller, 1998). In the end however, despite the fact that 20% of the HLC students' course grades were assessed via the more complex constructed-response questions, their semester or end-of-course scores were comparable with the MLC students. The fact that the semester grades were not statistically significant between the two groups suggests that students are equally as capable of rising to the challenge of and successfully applying their HOCS as they generate their own answers in a variety of formats as they are with applying their LOCS in fixed-answer formats. Though end-of-course scores may not be the most discerning approach for comparing these two groups, as Crowe et al., (2008) explain, the development of HOCS related teaching strategies constitute only one part of the equation. Equally as important is the development of assessments which can effectively measure the efficacy of the strategies.

Student Perceptions

For our third question, as evidenced in Table 5, in contrast to the work done by Walker *et al*. 2008, among others, the student evaluation data demonstrated that the students who participated in the HLC class were as receptive to the learner-centered methods as the students in the MLC class. As discussed in the introduction, one of the significant drawbacks cited by both opponents and advocates of implementing learner-centered methods has been student resistance. Thus it is interesting to note that the HLC section was given lower marks in Organization and Explanation of Materials (OEM) and higher marks in Self-Regulated Learning (SRL) and that the Learning Environment (LE) scores were almost identical for both sections. The lower marks in OEM for the HLC class may be reflective of the more variable structure of the group projects and the fact that these projects entailed a large portion of the work being completed independently in and out of the classroom. In addition rubrics were used to grade group assignments and are often perceived to be more subjective than traditional objective evaluations like those used in the MLC class (Rodriguez, 1993). However, in this study students demonstrated they were as receptive overall to the HLC methods as to the MLC methods. These results may well indicate that students are more willing to accept the intellectual challenge of engaging in and directing their own learning and/or, that as varying degrees of integrated learner-centered methods are being introduced in a variety of courses, students are becoming more familiar with and thus more accepting of HLC environments. An argument can be made, however, that these results could, at least in part, be the consequence of class size rather than degree of learner-centeredness. Though still large, the HLC class consisted of less than half the number of students than the MLC class (82 and 211 respectively) and researchers have reported consistently higher student evaluations in smaller classes (Chapman & Ludlow, 2010).

Conclusions

This study serves to further substantiate much of what has already been evidenced concerning the positive effects of learner-centered instruction. As with previous studies, this study demonstrated that actively engaging and encouraging students' use of (HOCS) provides students with opportunities to think critically, problem-solve effectively, and retain knowledge efficiently.

In contrast to previous studies, however, this study posits that student opposition to higher degrees of integrated learner-centered methods is waning. The students' evaluation of the MLC class was essentially identical to the students' evaluation of the HLC class. These results, though potentially influenced by class size, bode well for both the implementation and acceptance of higher degrees of learner-centered instruction within large lecture classrooms.

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APPENDIX A

POST-TEST

Environmental Science: BIOL 1132.004
Comprehensive Final Exam
(Items in red were comprised the 37 missed questions)(* Items were considered Application question per Bloom's)

1. One problem associated with pesticides is that they:
   a) do not stay where they are applied.
   b) tend to move through water and soil.
   c) may move great distances from the point of application.
   d) can be transported through the atmosphere.
   e) All of the above.

2. Pollution that is discharged into the environment through pipes, sewers, or ditches is called:
   a) nonpoint source pollution.
   b) Specific discharge.
   c) Polluted runoff.
   d) Point source pollution.
   e) Effluent runoff.

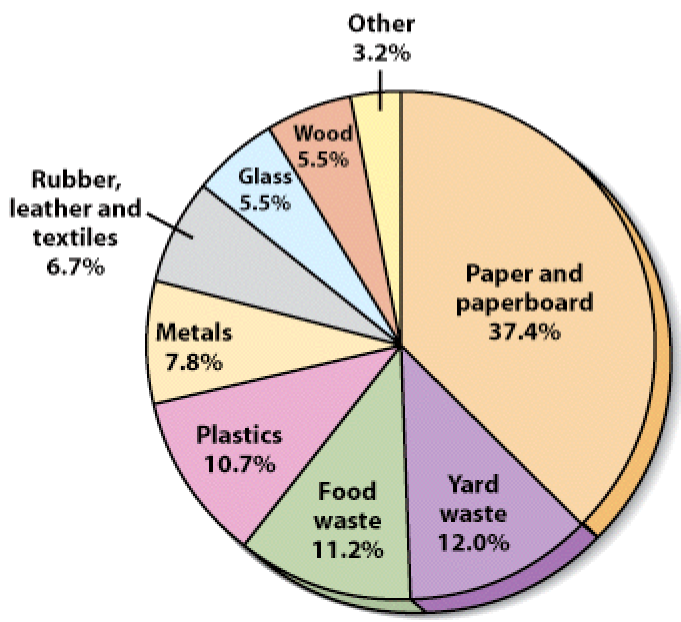
3. The interdisciplinary study of humanity's relationship with other organisms and the non-living physical environment is termed:
   a) Environmental science.
   b) Political science.
   c) Risk analysis.
   d) Ecology.
   e) Sociology.

4. The ability of a community to withstand environmental disturbances (community stability) is a consequence of:
   a) Sheer luck.
   b) Power of keystone species.
   c) Species richness
   d) Species poverty
   e) Geographic size of community

5. Organisms that provide an early warning of environmental damages are:
   a. Bellwether species.
   b. Endemic species.
   c. Threatened species.
   d. Commercial species.
   e. Endangered species.

6. The concern that the largest number of landfills, incinerators, and sewage treatment plants are found in low-income communities raises issues of:
    a. Environmental justice
    b. Voluntary simplicity
    c. Phytoremediation
    d. Environmental economics
    e. Racial prejudice

7. The pie chart below shows the composition of municipal solid waste. The largest component of this waste is:



Composition of municipal solid waste.

a) paper and paperboard b) plastics c) glass d) metals

8. *Use the associated table to determine which of the following water temperatures will have the greatest quantity of dissolved oxygen available to aquatic animals.

Temperature (^{oC})	Dissolved Oxygen (g/L)
0	0.0141
10	0.0109
20	0.0092
25	0.0083
30	0.0077
35	0.0070
40	0.0065

a. 25 ^{oC} b) 20 ^{oC} c) 10 ^{oC} d) 30 ^{oC} e) 40 ^{oC}

9. A preservationist is more likely to have a _______________worldview, and a conservationist probably has a ___________ worldview.
    a. Self-centered, unselfish
    b. Biocentric, eccentric
    c. Anthropocentric, biocentric
    d. Universal, rare
    e. Biocentric, utilitarian

10. Pollution is considered an external cost because:
    a. Its cost to the environment is not reflected in the price of the product that produces it.
    b. It is a hidden cost that would produce increased demand if the consumer were aware of it.
    c. It is an advertised cost that may affect consumer demand for a given product.
    d. It has a harmful effect borne only by people who purchased the product that caused it.
    e. It has a significant impact on the consumer's decision to buy the product that causes it.

11. Stratospheric ozone is important because it:
    a. Is an industrial pollutant.
    b. Is what we breathe.
    c. Absorbs UV radiation.
    d. Is part of the troposphere.
    e. Powers the weather cycle.

12. Thermal pollution:
    a. is linked to agricultural run-off.
    b. Only impacts the respiration of fishes and other aquatic animals.
    c. Decreases the amount of dissolved oxygen.
    d. Has little effect on smaller aquatic organisms.
    e. Greatly increases sedimentation.

13. In economic terms, pollution can be defined as:
    a. Resource degradation.
    b. A source.
    c. Natural capital.
    d. Overuse of sinks.
    e. None of the above.

14. Which of the following activities is responsible for the largest percentage of human-made carbon dioxide emissions?
    a. Burning fossil fuels.
    b. Ozone depletion.
    c. Acid deposition.
    d. Agriculture.
    e. Deforestation.

15. Urban areas receive less sunlight than rural areas, partly as a result of greater quantities of _____________in the air.

    a. Ozone
    b. Sulfur oxides
    c. Nitrogen oxides
    d. Hydrocarbons
    e. Particulate matter

16. Combustion of which of these fossil fuels is/are linked to global warming?

    a. Oil
    b. Natural gas
    c. Coal
    d. Methane
    e. All of the above

17. An ecosystem can be characterized as:

    a. All of the biological interactions, plus interactions with the abiotic environment, in a given area.
    b. Populations + community.
    c. Interactions between physical processes and the abiotic environment.
    d. The abiotic components of the environment.
    e. All species, population, and community interactions for organisms in a given area.

18. National income accounts are incomplete estimates of national economic performances because national income accounts do NOT include:

    a. Gross domestic product.
    b. Estimates of human manufactured material goods.
    c. Net domestic product.
    d. Estimates of external costs such as natural resource depletion and the environmental cost of economic activities.
    e. Estimates of imported goods and services.

19. *A state agency has contacted you to do a scientific assessment of kudzu in a nature preserve in southern Georgia. They are concerned about the effects of the non-native invasive vine on a small rare plant that grows on the forest floor in the preserve, but which is found nowhere else in the state. Kudzu is only growing on the east side of the preserve because it hasn't yet had time to invade further.

    Site 1. On the east side of the park with the kudzu, you set up ten 1m x 1m plots on the forest floor. In each plot you count the number of individuals of the rare plant.

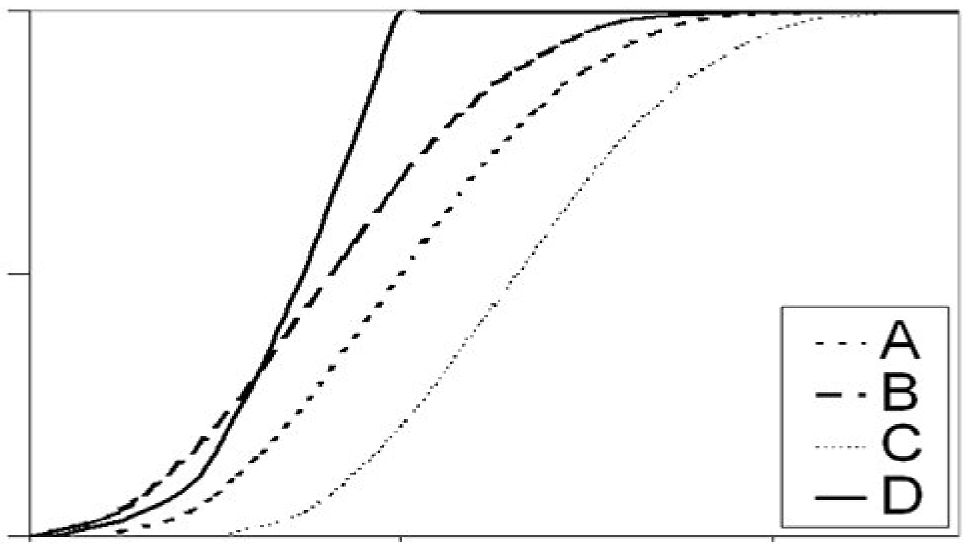
    Site 2. On the west side of the park without the kudzu, you set up ten 1m x 1m plots on the forest floor. In each plot you count the number of individuals of the rare plant.

    Based solely on the data represented in the associated table, what can you report to the agency that contracted you to do this study?

Site	Mean number of individuals of rare plant per plot
Site 1	1.7
Site 2	4.2

a. Kudzu is shading out the rare plant.
b. Kudzu grows much faster than the rare plant and will dominate the preserve within a decade.
c. The rare plant is unaffected by the presence of the kudzu.
d. It will be impossible to remove kudzu from the park because it grows too fast.

20. *Examine the graph and determine which chemical is the most toxic.



a. Curve A
b. Answer cannot be determined using this graph.
c. Curve B
d. Curve C
e. Curve D

21. The greatest problem with the use of nuclear power to generate electricity is its production of:

a. Radiation that is released into the surrounding region.
b. Radioactive waste that requires waste storage.
c. Air pollutants.
d. Water pollution.
e. Carbon dioxide.

22. High fertility rates are generally encouraged in developing countries because:

a. Children contribute to the family's livelihood.
b. Children must care for aging parents
c. Male children are culturally more desirable, so families continue to have children until male children are born.
d. High fertility rates compensates for high infant mortality rates.
e. All of the above.

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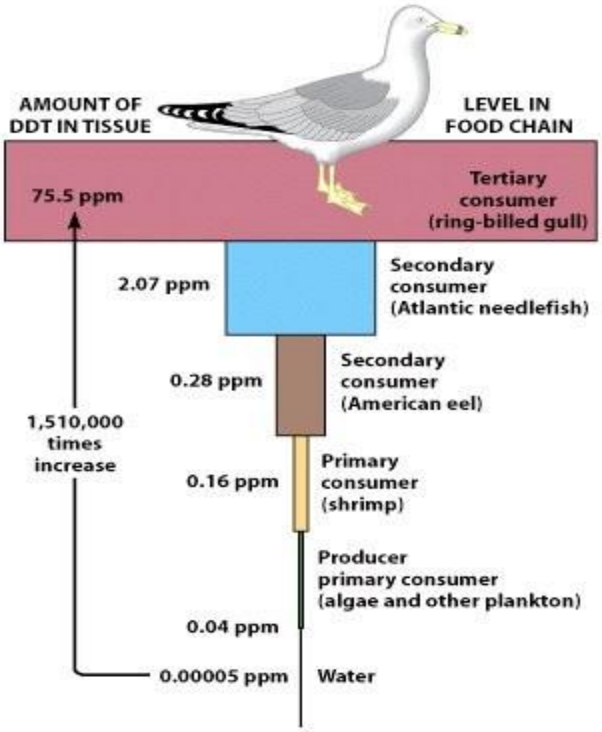
23. In the associated figure, the full has the highest concentration of DDT because it is:



a. A more complex organism.
b. Homoeothermic (warm-blooded).
c. At the top of the food chain.
d. An older organism.
e. At the bottom of the food chain.

24. The buildup of pesticides in an organism's body is termed

a. The pesticide treadmill.
b. Bioaccumulation.
c. Biological magnification.
d. Genetic resistance.
e. Persistence.

25. All of the following are renewable energy sources EXCEPT:

a. Biomass.
b. Solar.
c. Wind.
d. Nuclear power.
e. Hydroelectric.

26. Today the world's main energy source is:

a. Coal
b. Hydroelectric
c. Nuclear
d. Natural gas

e. oil

27. The difference between primary and secondary pollutants is that primary air pollutants:
    a. Are the direct results of natural processes, whereas secondary air pollutants are the result of human activity.
    b. Are not harmful to humans, whereas secondary air pollutants may be toxic to humans.
    c. Only affect plants, while secondary pollutants affect plants and animals.
    d. Enter the atmosphere directly, whereas secondary pollutants form from substances released into the atmosphere.
    e. Are smaller, primary molecules.

28. *A primary consumer would eat:
    a. Bacteria.
    b. Secondary consumers.
    c. Rabbits.
    d. Plants.
    e. Herbivores.

29. The concern about global warming is directly related to increased levels of what chemical in the atmosphere?
    a. carbon dioxide
    b. Mercury
    c. chlorofluorocarbon
    d. sulfur oxide
    e. nitrogen oxide

30. A secondary consumer would eat:
    a. Herbivores.
    b. Tertiary consumers.
    c. Fungi.
    d. Lions.
    e. Bacteria.

31. What is the correct sequence of steps in the scientific method?
    I. State the problem
    II. Analyze and interpret the data
    III. Develop a hypothesis
    IV. Share the results with others
    V. Design and perform an experiment to test the hypothesis

    a. III – I – V – II – IV
    b. I – III – V – II – IV
    c. V – II – I – III – IV
    d. I – II – III – IV – V
    e. V – IV – III – II - I

32. The greenhouse effect occurs because:
    a. Carbon dioxide and other trace gases trap infrared radiation in the Earth's atmosphere.
    b. The gases produced by human activities allow significantly more heat to pass out of the Earth's atmosphere.
    c. Sulfur emissions from smokestacks and volcanoes continue to occur.
    d. Greenhouse gases released interact chemically to produce excess heat.
    e. There are too many greenhouses scattered across the Earth's surface.

33. Which of the following is **NOT** *critical* for a balanced ecosystem?
    a. Consumers
    b. Humans
    c. Producers
    d. Decomposers
    e. Plants

34. Which of the following represents a resource that could be characterized as a present-day "commons?"
    a. Fresh water
    b. Atmosphere
    c. Forests
    d. Marine fisheries
    e. All of the above

35. The maximum number of individuals of a given species that a particular environment can support for an indefinite period, assuming there are no changes in the environment is called its:
    a. Demography.
    b. Environmental resistance.
    c. Sustainability.
    d. Carrying capacity.
    e. Intrinsic rate of increase.

36. The theory of evolution by natural selection was proposed in *The Origin of Species by Means of Natural Selection* (1859), written by:
    a. Charles Darwin
    b. Aristotle
    c. G.F. Gause
    d. Rachel Carson
    e. Ponce de Leon

37. The human population is increasing because of:
    a. Medical advances.
    b. Agricultural advances.
    c. Sanitation practices.
    d. Improved water quality.
    e. All of the above.

38. *Which of the following best illustrates the process of evolution?

   a. A population of foxes increases as more prey becomes available.
   b. A plant loses its leaves in a drought.
   c. A lizard's color becomes brown as it sits on a log.
   d. A bear goes into hibernation.
   e. A population of mosquitoes develops resistance to a pesticide.

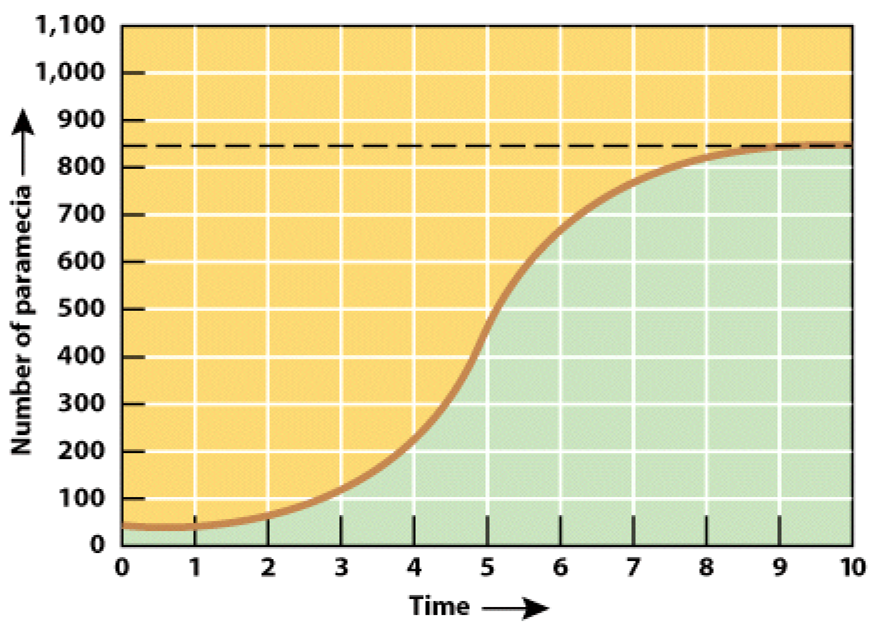
39. Which of the following series is organized according to the levels of organization used by ecologists?

   a. Population – ecosystem – community
   b. Species – community – abiotic factors
   c. Population – community – ecosystem
   d. Species – ecosystem – population
   e. Population – community – biotic factors

40. An improving economy in a country is generally correlated with:

   a. Increased birth rate and increased population growth rate.
   b. Decreased birth rate and increased population growth rate.
   c. Decreased birth rate and decreased population growth rate.
   d. Decreased death rate and increased population growth rate.
   e. Increased death rate and decreased population growth rate.

41. The flat area at the top of the graph indicates that the



   a. Population has reached its biotic potential.
   b. Environmental resistance is low.
   c. Population has reached its carrying capacity.
   d. Population is growing exponentially.

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42. The pathway by which carbon is transferred from living organisms to the atmosphere is called:

    a. Burning fossil fuels.
    b. Cellular respiration.
    c. Photosynthesis.
    d. Transpiration.
    e. Evaporation.

43. In the scientific method, a hypothesis:

    a. Is a statement of fact.
    b. Makes a prediction that can be tested.
    c. Is usually proven to be correct.
    d. Can only be tested once.
    e. All of the above.

44. A brownfield is an urban area of:

    a. Sports arenas for baseball, football, and soccer.
    b. Abandoned, vacant factories, warehouses, and residential sites that may be contaminated from past uses.
    c. Vacant house lots that are overgrown with weeds and vegetation.
    d. Meadows that are earmarked for industrial development.
    e. Parking lot pavement that collects heat during the day and emits heat at night.

45. The Earth's atmosphere is important because:

    a. It protects us from UV radiation and X-rays.
    b. It is primarily composed of oxygen, essential for our survival.
    c. It is composed of approximately twenty different layers.
    d. It is a staple and unchanging part of our global environment.
    e. The most dense outer later shields the Earth's surface from dangerous forms of energy.

46. Plastics are the fastest growing component of solid waste, large due to the contribution of:

    a. Obsolete computers.
    b. Disposable diapers.
    c. Clothing.
    d. Discarded automobiles.
    e. Packaging.

47. The stratospheric chemical that prevents much of the solar ultraviolet radiation from penetrating to Earth's surface is:

    a. Nitrogen oxides.
    b. Particulate matter.
    c. Carbon dioxide.
    d. Water vapor.
    e. Ozone.

48. Every ton of recycled paper saves approximately:

    a. 17 trees.
    b. 7000 gallons of water.
    c. 4100 kilowatt-hours of energy.
    d. 3 cubic yards of landfill space.
    e. All of the above.

49. Risk:
    a. Is the probability of injury, disease, death, or environmental damage under a given set of circumstances.
    b. Does not apply to routine, everyday activities.
    c. Only applies to environmental impact on human health and welfare.
    d. Is the probability that a given hypothesis will be proven true.
    e. Is an assessment of the financial cost of environmental impact.

50. The First Law of Thermodynamics states that:

    a. Energy cannot be created or destroyed.
    b. Energy transfer between organism is inefficient and much energy is lost
    c. The organization of the universe is steadily increasing.
    d. Energy can be created or destroyed by physical processes.
    e. Entropy always increases.

51. Examples of non-sustainable human activities or behaviors include:

    a. Use of nonrenewable resources as if they were present in unlimited quantities.
    b. Using technology to improve car mileage.
    c. Conservation practices.
    d. Recycling.
    e. Attempts to limit human population growth.

52. All of the following represent ways in which individuals can reduce water consumption except:

    a. Installing low-flush toilets.
    b. Washing many small loads of laundry.
    c. Using a dishwasher.
    d. Installing low-flow showerheads.
    e. Turning the facet off while brushing teeth.

53. *What factors should be considered to make an "ideal" sanitary landfill?

    a. Geology.
    b. Proximity to nearby surface and ground water.
    c. Proximity to population centers but far enough to not be offensive.
    d. Does not require high transportation costs to deliver solid waste.
    e. All of the above.

54. The most promising solution to our current and future energy needs is:

    a. Photovoltaic technology.
    b. Wind farms.

c. Geothermal energy.
d. Direct and indirect solar power.
e. Conservation and increased efficiency.

55. Integrated waste management refers to:

a. Handling problems of household, industrial, and sewage wastes all together.
b. The principle of dilute and disperse.
c. National programs of source reduction.
d. Proper disposal of household hazardous wastes.
e. Waste management techniques that involve reusing, recycling, and reducing.

56. Worldwide, freshwater use is:

a. Relatively stable due to offsets between individual use and industrial conservation.
b. Increasing because, on average, each person is using more water.
c. Decreasing because, on average, agriculture is conserving more water.
d. Decreasing due to the decline in the global population growth rate.
e. Decreasing due to improved technology and greater efficiency.

57. Which of the following is NOT a renewable source of energy?

a. Fossil fuels
b. Hydropower
c. Direct solar
d. Wind
e. Biomass

58. The main cause of under nutrition and malnutrition is:

a. Inadequate global food production.
b. Decreasing livestock yields.
c. Polyculture.
d. Organic farming practices.
e. Poverty.

59. The energy consumption of each person in highly developed countries:

a. Is four times as much as each person in developing countries.
b. Is eight times as much as each person in developing countries.
c. Cannot be compared because people in developing countries don't use energy.
d. Is about the same as each person in developing countries.
e. Is twice as much as each person in developing countries.

60. Which of the following correctly identifies one of the goals of waste prevention?

a. Decrease dematerialization
b. Increase reuse of products
c. Decrease recycling of packaging materials
d. Increase use of disposable items
e. Increase consumption

61. *If you measured the LD_{50} for a particular chemical, you would know:

    a. How much it takes to kill 50 rats.
    b. The effective dose for humans.
    c. What dose is lethal to 50% of a population of test animals.
    d. That the chemical is safe for human use.
    e. The chemical properties of the given chemical

62. One advantage of conventional nuclear power, when compared to coal, is:

    a. Emission of few pollutants to the atmosphere.
    b. No related occupational death.
    c. Unlimited supply.
    d. No connection to water pollution.
    e. Limited risk from catastrophic accidents.

63. In solving environmental problems, a risk analysis is usually performed:

    a. To analyze the potential effect of an intervention or doing nothing.
    b. To provide public awareness and endorsement.
    c. A risk analysis is not necessary in resolving environmental problems.
    d. To monitor the initial assessment and modeling of the problem.
    e. To solicit public opinion about how evidence should be interpreted when selecting a course of action.

64. We depend on water for all of the following except:

    a. Manufacturing.
    b. Travel.
    c. Energy production.
    d. Mining.
    e. None of the above, we depend on water for all of these.

65. An environmental impact statement must include:

    a. Solutions to any potentially adverse environmental effects.
    b. Short- and long-term effects and any adverse environmental effects.
    c. Documentation of the financial cost-benefit analysis of the proposed action.
    d. A description of the solution to any associated environmental controversy.
    e. An ethical analysis of the proposed action.

66. Which of the following statements is true?

    a. Predation only favors the predator with the evolution of more efficient ways to catch prey.
    b. Predation has no evolutionary consequences for either the predator or the prey.
    c. Predation only favors the prey with the evolution of more efficient ways to escape predators.
    d. Predation exerts a selective force on the prey, favoring characteristics that reduce the probability of capture.
    e. Predation exerts a selective force on the predator, favoring characteristics that reduce the probability of prey capture.

67. A large amount of sewage:

a. Generates a high BOD, which lowers the level of dissolved oxygen in the water.
b. Does not effect the BOD.
c. Generates a low BOD, which raises the level of dissolved oxygen in the water.
d. Generates a low BOD, which lowers the level of dissolved oxygen in the water.
e. Generates a high BOD, which raises the level of oxygen in the water.

68. Elements or groupings of elements that occur naturally in the Earth's crust are called:

a. Minerals.
b. Compounds.
c. Metals.
d. Atoms.
e. Ores.

69. The ability to meet humanity's current needs without compromising the ability of future generations to meet their needs is:

a. Synergism.
b. Natural balance.
c. Ecology.
d. Environmental science.
e. Environmental sustainability.

70. Soil is formed from parent material by biological, chemical, and physical:

a. Digestion processes.
b. Leaching.
c. Terracing.
d. Weathering processes.
e. Composting.

71. Why are tropical rain forests considered so important to global ecology?

a. They contribute greatly to the world's carbon and oxygen cycles.
b. They retard soil erosion.
c. They contain much of the world's biodiversity.
d. They mitigate floods and droughts.
e. All of the above.

72. The long-term solution to the food supply problem is to:

a. Control human population growth.
b. Implement the use of genetically engineered crops and livestock.
c. Expand organic farming.
d. Develop and then utilize genetically diverse varieties of various crops.
e. Expand energy-intensive agricultural methods that produce high yields of food.

73. "The Tragedy of the Commons" refers to:

a. An environmental theory promoting public ownership of lands and resources.

b. Events impacting the common people, particularly farmers, of developing countries.
c. An economic theory promoting private ownership of lands and resources.
d. Environmental problems generated by farming practices.
e. An analogy describing the conflict between individual interest and management of shared resources.

74. Bioaccumulation is the buildup of a persistent pesticide in ________________.

a. Oceans and seas; lakes and ponds
b. An individual's blood stream; an individual's fatty tissues.
c. Plants; animals
d. Living tissue; air, water, and soil
e. An individual organism's body; organisms at the top of the food chain.

75. The single greatest threat to biological diversity is:

a. The introduction of foreign species.
b. Air pollution.
c. Water pollution.
d. Overexploitation.
e. Habitat loss.

Appendix B

Scientific Method Student Rubric

Group Assignment #1: The Scientific Method

<u>Instructions</u>

A) Read the article given in class.
B) Describe the steps of the scientific method in detail,

AND

C) Find all components of the scientific method as given in this article.
Use the following as a guideline to help you:
1. What is the problem/unanswered question?
2. What was the testable hypothesis the scientists chose?
3. What experiments did they use to test the hypothesis?
4. How did they analyze and interpret the data?
5. What conclusions do the scientists wish to convey to the public?

<u>Mechanics</u>

This assignment must be typed using 12 point font; double-spaced; between 300-500 words.
This assignment is due IN CLASS. Late submissions will result in point deductions (-10% per day late). You have one week from the assignment <u>deadline</u> to turn in the assignment for credit.

Use the Rubric below to see the point distributions.

Content and Development ***10 Points***	*Points Earned* *XX/10*
	Additional Comments:
The student covers all key elements of the assignment in a substantive way. The student: • explains the processes of the **scientific method** as used in the journal article • explains each step of the scientific method	
The student is comprehensive, accurate, and persuasive. • The paper is **300-500** words in length.	
The student develops a central theme or idea directed toward the appropriate audience. • The steps of the scientific method are applied to a scientific study.	
The student links theory to relevant examples and uses the vocabulary of the theory correctly.	

The student states major points clearly with specific details, examples, or analysis; and organizes logically.	
The **introduction** provides sufficient background on the topic and previews major points.	
The **conclusion** is logical, flows from the body of the paper, and reviews the major points.	
Readability and Style ***5 Points***	*Points Earned* *X/5*
	Additional Comments:
Paragraph transitions are present, logical, and maintain the flow throughout the paper.	
The tone is appropriate to the content and assignment.	
Sentences are complete, clear, and concise.	
Sentences are well constructed, strong, and varied.	
Sentence transitions are present and maintain the flow of thought.	
Mechanics ***5 Points***	*Points Earned* *X/5*
	Additional Comments:
The paper, including the **title page**, reference page, tables, and appendixes, follows APA formatting guidelines.	
Citations of original works within the body of the paper follow APA guidelines.	
The paper is laid out with effective use of headings, font styles, and white space.	
Follows the rules of grammar, usage, and punctuation.	
Spelling is correct.	
Total ***20 Points***	*Points Earned* *XX/20*
Overall Comments:	

Appendix C

Risk Analysis Student Rubric

Content and Development ***10 Points***	*Points Earned* *XX/10*
Risk Assessment Paper	Additional Comments:
The students covers all key elements of the	

assignment in a substantive way. The student: • explains each step of Risk Assessment thoroughly • answers all questions indicated in the instructions • develops a clean-up strategy	
The students are comprehensive, accurate, and persuasive.	
The students develop a central theme or idea directed toward the appropriate audience. • Educate the general public about existing presence of your toxicant	
The students link theory to relevant examples and use the vocabulary of the theory correctly.	
The students state major points clearly with specific details, examples, or analysis; and organize logically.	
Readability and Style ***5 Points***	*Points Earned* *X/5*
	Additional Comments:
Paragraph transitions are present, logical, and maintain the flow throughout the paper.	
The tone is appropriate to the content and assignment.	
Sentences are complete, clear, and concise.	
Sentences are well constructed, strong, and varied.	
Sentence transitions are present and maintain the flow of thought.	
Mechanics ***5 Points***	*Points Earned* *X/5*
	Additional Comments:
The paper, including the title page, reference page, tables, and appendixes, follows APA formatting guidelines. (tables/appendices used when necessary)	
Citations of original works within the body of the paper follow APA guidelines.	
The paper is laid out with effective use of headings, font styles, and white space.	
Follows the rules of grammar, usage, and punctuation.	
Spelling is correct.	
Total ***20 Points***	*Points Earned* *XX/20*
Overall Comments:	

Appendix D

Six Week Project Outline

I. Descriptive Study: *A study on greenhouse gas carbon reduction by reducing gasoline consumption.*

II. Methods:

a. What you plan to do:

i. Drive my car one day less per week

b. How you plan to carry out your study:

i. I will consolidate running errands, ride the bus, car pool, etc.

c. What effects you expect to have:

i. My car (Nissan Xterra) gets 14 miles to the gallon in the city and 20 mpg on the highway for a combined MPG of 16, according to the US Department of Energy at www.fueleconomy.gov. Furthermore, according to this source, my vehicle consumes 21.4 barrels or 898.802 gallons of petroleum and produces 11.4 tons (22,800 pounds) of greenhouse gas emissions per year. (These estimates are based on 45% highway and 55% city driving for 15,000 annual miles.)

ii. On average, based on the above calculations, I drive approximately 41.1 miles a day for 365 days (365 X 41.1 = 15,001.5 miles per year) or 287.7 miles per week. This also equates to 62.47 lbs of greenhouse gas emissions per day and 437.26 lbs of greenhouse gases per week.

iii. My goal is to reduce my weekly driving load by at least 41.1 miles per week, which would equate to a reduction of 62.47 lbs of green house gases for the week and a total reduction of 374.82 lbs for the six week study.

d. When you will carry out your plan

i. I will begin this project on (<u>specific date</u>) and will end it six weeks from now on (<u>specific date</u>).

III. Procedures

(Here you provide DETAILS about what you actually have done!!) For instance:

a. Today is _______________. This day will serve as the beginning of Week 1 for this study. I set my trip odometer to 0 today.

b. Today is _________________. I am choosing not to drive or ride in another car today.

c. Today is ________________. This is the seventh and final day of Week 1. According to my trip odometer, I drove ________________miles this week.

d. Today is _________________. This day will serve as the beginning of Week 2 for this study. I set my trip odometer to 0 today.

e. Today is ___________________. I am choosing not to drive or ride in another car today.

f. Today is _______________. This is the seventh and final day of Week 2. According to my trip odometer, I drove _______miles this week.

(ETC. for the remaining 2 weeks of the study)

IV. Results

a. According to my resource (www.fueleconomy.gov) the average usage for my vehicle (Nissan Xterra) is 15,000 miles per year, which equates to a contribution of 11.4 tons of greenhouse gases per year.

b. Based on my study, I found that on average I actually drive ___________miles per week. This amount is (<u>more/less</u>) than the average provided by my resource. Due to this (<u>increase/decrease</u>) in use, I found that I contribute approximately ____________lbs of greenhouse gases (<u>below/above</u>) the average.

V. Implications

a. During my four week study, I found that I contributed approximately ___________lbs of greenhouse gases to our environment.

b. If everyone in the US contributed as much as I do, then our national gasoline based greenhouse gas emissions would be equal to ___________lbs. per year. (US population is 307,595,506 as of 19:51 GMT on Oct. 1, 2009) (www.census.gov/main/www/popclock.html)

c. This amount (re state amount here) is currently _________lbs (above/below) the average provided by my resource (www.fueleconomy.gov)

d. If everyone in the US were to drive a vehicle like mine and were to reduce their driving by at least (41.1)(insert the amount of miles you actually reduced for yourself) miles per week, this would equate to a carbon reduction (gasoline based greenhouse gases) of ________________lbs per year if our population were to stay exactly the same as it is as of this writing.

VI. Final Conclusions

(share your thoughts here)