



The effectiveness of pre-tests and post-tests for teaching industrial ecology in an engineering management program

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ABSTRACT

This study aims to evaluate the effectiveness of using pre-tests and post-tests combined with interactive teaching methods to enhance student engagement and understanding in an Industrial Ecology course within an Engineering Management program. Given the theoretical nature of the subject matter, this research seeks to address student disengagement and boredom by integrating regular assessments and group activities. The study was conducted with a cohort of students enrolled in the Industrial Ecology course. A structured lecture format was employed, incorporating pre-tests at the beginning of each class, followed by theoretical presentations, post-tests, and interactive group assignments. The pre-test and post-test questions were identical to assess retention and attention. Student engagement was measured through participation rates, test scores, and feedback surveys. Group activities were designed to foster discussion and critical thinking, with peer evaluations conducted to ensure active participation. The results indicated a significant improvement in student engagement and understanding. The average post-test scores increased by 20% compared to pre-test scores, demonstrating enhanced retention of the material. Student feedback revealed a higher level of interest and motivation, attributing it to the interactive and structured nature of the classes. The novelty of this approach lies in the systematic use of pre-tests and post-tests to maintain attention and the integration of interactive elements to counteract theoretical boredom, offering a practical solution for similar educational contexts.

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INTRODUCTION

The challenge of student disengagement in theoretically intensive courses, particularly at advanced levels of education, is well-documented. In the Industrial Ecology course within the Engineering Management program at Institut Teknologi Del, students have expressed boredom and lack of interest due to the heavy theoretical content, which they last encountered in high school. This issue is more pronounced compared to other courses in the Engineering Management program, which

often include more practical applications like case studies, simulations, and hands-on projects. Such disengagement poses a significant barrier to effective learning and comprehension (Freeman et al., 2014). Traditional teaching methods, particularly lectures, have been shown to fall short in enhancing student engagement and understanding in theoretically intensive courses. Students often find lectures monotonous and disengaging, especially when the material is heavily theoretical and abstract (Lombardi et al., 2021; Wong & Liem, 2022). Therefore, this research aims to address this issue by implementing a structured teaching methodology that combines pre-tests, post-tests, and interactive group activities to enhance student engagement and understanding.

Student engagement is crucial for effective learning, especially in subjects that involve complex and abstract concepts. When students are not engaged, they are less likely to retain information and apply it in practical situations. Traditional lecture-based approaches often fail to capture the attention of students, leading to poor academic performance and a lack of interest in the subject matter (Lombardi et al., 2021; Vermeulen & Volman, 2024; Wong & Liem, 2022). The Industrial Ecology course at Institut Teknologi Del is a core course within the program. However, unlike other core courses, the material before the midterm exams is heavily based on biological concepts. Students in the Engineering Management program have not had biology courses since entering the program, leading them to perceive this content as irrelevant to their field of study and future careers. This perception creates a disconnect between the course material and their primary area of interest, resulting in decreased engagement and motivation. This disengagement is more pronounced compared to other courses in the Engineering Management program. By incorporating interactive elements and regular assessments, educators can create a more dynamic and engaging learning environment that encourages active participation and continuous feedback (Chen et al., 2024).

Research has shown that active learning strategies, such as pre-tests, post-tests, and interactive group activities, can significantly improve learning outcomes and student satisfaction (Johnson & Johnson, 2009; Munna et al., 2021; Singh et al., 2022). These strategies are designed to promote student interaction and participation, thereby increasing engagement. Pre-tests and post-tests are effective tools for measuring students' knowledge before and after a learning activity, respectively. The primary purpose of these tests is to gauge the effectiveness of instructional methods and track students' progress (Alessandri et al., 2017; Choi & Lee, 2020; Murphy et al., 2023; Strelan et al., 2020). Feedback from these assessments helps identify areas that need improvement and ensures that learning objectives are being met (Agarwal et al., 2021; Bertilsson et al., 2020; Latimier et al., 2019).

Interactive group activities involve collaborative learning where students work together to solve problems, discuss concepts, and engage in meaningful tasks. This method is grounded in social constructivist theories which posit that learning is a social process and that knowledge is constructed through interaction with others (Daniel et al., 2024; Deysolong, 2023; Taggart & Wheeler, 2023). Group activities have been shown to enhance critical thinking, communication skills, and a deeper understanding of the subject matter (Johnson & Johnson, 2009).

The primary research questions guiding this study are: How effective are pre-tests and post-tests in enhancing student engagement and retention of course material in an Industrial Ecology course? Can interactive group activities increase student participation and understanding in a theoretically intensive course? To tackle the problem of student disengagement, this study adopts a mixed-method approach. Pre-tests and post-tests are used to measure students' retention and understanding of the material presented during lectures. These tests are coupled with interactive teaching methods, including group assignments and discussions, to foster a more engaging and participatory learning environment. By analyzing the test scores and student feedback, the study seeks to evaluate the effectiveness of these methods in improving student engagement and comprehension (Pan & Carpenter, 2023).

The objectives of this research are to assess the impact of pre-tests and post-tests on student engagement and retention in an Industrial Ecology course, to evaluate the effectiveness of interactive group activities in enhancing student participation and understanding, and to provide evidence-based recommendations for teaching methods that can improve engagement and learning outcomes in theoretically intensive courses. Previous studies have shown that active learning strategies, such as interactive teaching and regular assessments, can significantly improve student engagement and learning outcomes (Freeman et al., 2014; Lombardi et al., 2021; Schnitzler et al., 2021). The use of pre-tests and post-tests has been found to promote better retention and understanding of material by encouraging continuous engagement and feedback (Agarwal et al., 2021; Bertilsson et al., 2020). Theories on retention, such as the encoding specificity principle and the spacing effect, suggest that the manner and frequency of exposure to information significantly impact memory retention (Aji & Khan, 2019; Merugu et al., 2023; Yanes et al., 2019). Moreover, group activities and peer discussions are effective in fostering critical thinking and collaborative learning (Johnson & Johnson, 2009).

It is anticipated that the structured teaching approach incorporating pre-tests, post-tests, and interactive activities will lead to higher levels of student engagement and improved understanding of the course material. The findings of this study could provide valuable insights for educators in similar contexts, offering practical solutions to enhance the learning experience in theoretically intensive courses.

RESEARCH METHODOLOGY

This study employs a quantitative approach to evaluate the effectiveness of pre-tests, post-tests, and interactive group activities in enhancing student engagement and retention of course material in an Industrial Ecology course.

Design

The research design is a quasi-experimental pre-test-post-test control group design. The study involves two groups: an experimental group consisting of current students (60 students) who receive the intervention (pre-tests, post-tests, and interactive group activities), and a control group consisting of students from the previous year's cohort (41 students) who followed the traditional lecture-based approach. The design allows for comparison between the two groups to determine the effectiveness of the intervention (Ugalde et al., 2021).

Sample

The sample consists of 60 students enrolled in the Industrial Ecology course at Institut Teknologi Del for the current academic year (experimental group) and 41 students from the previous year's cohort (control group). The students, born between 2004 and 2005, were randomly assigned within their respective groups. The gender distribution and age of the sample are shown in Table 1.

Table 1. Demographic characteristics

Demographic Characteristics	Experimental Group (n=60)	Control Group (n=41)
Gender:		
Male	17	14
Female	43	27
Age:		
Born 2004-2005	60	41

Instrument

The instruments used in this study include pre-tests, post-tests for the experimental group, and the final grades (UTS, UAS, and final grades) for both groups: a) Pre-tests and Post-tests: These tests consist of essay questions covering key concepts of the Industrial Ecology course. The validity of the tests was supported by the use of standardized questions derived from widely recognized textbooks in the field of Industrial Ecology. These textbooks are known for their comprehensive coverage of the subject matter and are commonly used in academic settings to ensure that the questions adequately assess students' understanding of the course material. b) Final Grades: The final grades for both groups were used to compare the overall academic performance. These grades include midterm (UTS), final exams (UAS), and final course grades.

Data Collection

Data collection took place over one semester for the experimental group and retrospectively for the control group. To evaluate the increase in student engagement and understanding, the following specific metrics will be used: a) Participation Rates, the level of student participation in class activities, discussions, and group assignments will be recorded and compared between the experimental and control groups. b) Pre-test and Post-test Scores, the difference in scores between pre-tests and post-tests, given at each class meeting, will be analyzed to measure improvements in retention and understanding of the course material. An increase in post-test scores compared to pre-test scores will reflect enhanced understanding. c) Final Grades, the overall academic performance will be assessed through midterm (UTS) and final exams (UAS). Higher final grades will suggest better retention and comprehension of the course material. d) Feedback Surveys, student feedback will be collected through surveys to gauge their engagement, interest, and perception of the effectiveness of the new teaching methods. Positive feedback will indicate higher engagement and satisfaction. e) Peer Evaluations, during group activities, peer evaluations will be used to assess individual participation and contribution. Active involvement from all students, as reflected in positive peer evaluations, will indicate increased engagement.

The procedure is as follows: a) Pre-test Administration: The experimental group took the pre-test at the beginning of each class session to assess initial knowledge. b) Intervention: The experimental group participated in classes incorporating pre-tests, post-tests, and interactive group activities, while the control group attended traditional lecture-based classes. c) Post-test Administration: After a 40-minute lecture, post-tests are administered to measure retention of the material covered in the lecture. Upon completion, answer sheets are exchanged among students for peer grading, followed by a class discussion and evaluation of the answers. d) Group Activities and Discussions: The last hour of each class is dedicated to group assignments and discussions. Each group presents their task, followed by a question-and-answer session involving both the instructor and fellow students. Active participation is monitored and recorded. e) Final Grades: The UTS, UAS, and final course grades for both groups were collected and compared.

Data Analysis

The collected data were analyzed using descriptive and inferential statistics. Descriptive statistics include means and standard deviations for test scores and final grades. Inferential statistics include paired t-tests to compare pre-test and post-test scores within the experimental group, and independent t-tests to compare final grades between the experimental and control groups.

RESULTS AND DISCUSSIONS

The findings of this study are based on the data collected from the pre-tests, post-tests, and final grades (UTS, UAS, and final course grades) for both the experimental and control groups. The

results were obtained through a systematic analysis of these assessments: a) Experimental Group: Pre-tests were administered at the beginning of each class to assess initial knowledge, followed by a 40-minute lecture. Post-tests were then given to measure retention and understanding of the material. The final hour of each class involved interactive group activities, where students worked on assignments and participated in discussions. Participation rates and engagement levels were recorded through peer evaluations and feedback surveys. The final grades were derived from the midterm (UTS) and final exams (UAS), which covered all the material taught during the semester. b) Control Group: Students attended traditional lecture-based classes without pre-tests, post-tests, or interactive group activities. Their final grades were based on the same midterm (UTS) and final exams (UAS) as the experimental group. Comparison of final grades, participation rates, and feedback from both groups provided a comprehensive evaluation of the effectiveness of the intervention.

Pre-test and Post-test Scores (Experimental Group)

The pre-test and post-test scores for the experimental group, measured before and after each class, showed significant improvement. The average pre-test score was 65.4 (SD = 8.5), while the average post-test score was 85.2 (SD = 7.3). This 20% increase demonstrates enhanced retention and understanding of the material (see Table 2).

Table 2. Final grades comparison

Test	Mean (SD)
Pre-test	65.4 (8.5)
Post-test	85.2 (7.3)

Final Grades Comparison

The final grades, including UTS, UAS, and final course grades for both the experimental and control groups, are presented in Table 3. The experimental group's mean final grade was significantly higher than that of the control group, indicating the effectiveness of the new teaching methods.

Table 3. Final grades comparison

Group	UTS Mean (SD)	UAS Mean (SD)	Final Grade Mean (SD)
Experimental Group	80.5 (6.7)	85.0 (7.2)	88.5 (5.8)
Control Group	76.75 (8.56)	82.10 (7.92)	74.15 (8.25)

The experimental group's mean final grade was significantly higher than that of the control group. Additionally, the distribution of grades showed that all students in the experimental group achieved an A, while the control group had a range of grades including B and BC.

Discussion

Impact of Pre-tests and Post-tests on Student Engagement and Retention

The significant improvement in post-test scores for the experimental group suggests that the use of pre-tests and post-tests is effective in enhancing student retention of course material. These results are particularly noteworthy as they indicate that students in the experimental group were able to better retain and recall information. The pre-tests likely helped students identify areas where they needed to focus, while the post-tests provided motivation to review and consolidate their knowledge. This finding aligns with the retrieval practice theory, which posits that testing enhances long-term memory retention by reinforcing learning through repeated recall (Larsen et al., 2013).

Effectiveness of Interactive Group Activities

The higher engagement levels reported by the experimental group indicate that interactive group activities effectively increase student participation and interest. This result is significant because it demonstrates that students are more likely to engage with the course material when they are actively involved in learning activities. The group activities provided a platform for students to discuss concepts and solve problems collaboratively, which enhanced their understanding and made learning more enjoyable. This aligns with (Johnson & Johnson, 2009) findings that cooperative learning promotes higher academic achievement and better interpersonal skills. The students' feedback also highlighted that these activities made the classes more dynamic and less monotonous, contributing to a positive learning environment.

Comparison with Previous Studies

The results of this study support the conclusions of previous research that active learning strategies, such as pre-tests, post-tests, and interactive group activities, are more effective than traditional lecture-based approaches. Freeman et al., (2014) demonstrated that active learning significantly improves student performance in science and engineering courses. This study extends those findings to the context of an Industrial Ecology course within an Engineering Management program, addressing the specific challenge of student disengagement in theoretically intensive subjects. The novelty of this study lies in its integrated approach, combining pre-tests, post-tests, and interactive group activities in a single course. While previous studies have explored these strategies individually, this study demonstrates their combined effectiveness in enhancing both student engagement and retention.

Practical Implications

The findings of this study have practical implications for educators. Implementing regular pre-tests and post-tests, along with interactive group activities, can significantly enhance student engagement and retention of course material. These strategies can be particularly useful in courses that are perceived as heavy on theory and difficult to engage with. By incorporating these methods, educators can create a more interactive and supportive learning environment that encourages active participation and continuous feedback.

Limitations and Future Research

This study has several limitations. The sample size is relatively small, and the study is limited to one institution. Future research should involve larger samples across multiple institutions to validate these findings. Additionally, qualitative data could provide deeper insights into students' experiences and perceptions of these teaching methods. Future studies could also explore the long-term effects of these interventions on student learning outcomes and their applicability in different educational contexts.

CONCLUSION

This study demonstrated that the integrated use of pre-tests, post-tests, and interactive group activities significantly enhances student engagement and retention of course material in an Industrial Ecology course. The experimental group showed substantial improvements in test scores and higher engagement levels, indicating the effectiveness of these active learning strategies. Despite the study's limitations, such as the small sample size and single-institution focus, the findings provide valuable insights for improving teaching methods in theoretically intensive courses. The implications of this research are significant both in theory and practice. Theoretically, the study supports the effectiveness of active learning strategies, such as pre-tests, post-tests, and interactive group activities, in enhancing student engagement and retention. This aligns with the

retrieval practice theory and social constructivist theories, which emphasize the importance of active participation and social interaction in learning.

Practically, the findings provide actionable insights for educators in theoretically intensive courses. Implementing regular assessments and interactive elements can transform traditionally passive learning environments into dynamic and engaging ones, leading to improved academic outcomes and better preparation for professional challenges. Increased student engagement has significant long-term implications for both academic outcomes and professional readiness. Engaged students are more likely to retain and apply course material effectively, leading to improved academic performance and higher grades. Enhanced engagement also fosters critical thinking, communication, and collaborative skills, which are essential for professional success.

The structured teaching approach incorporating pre-tests, post-tests, and interactive activities not only boosts immediate learning outcomes but also prepares students for real-world challenges by promoting active learning and continuous improvement. Long-term, this approach can lead to more competent and motivated graduates, better prepared to tackle complex problems in their professional careers.

Future research should validate these results with larger samples and explore the long-term impact of these interventions. Additionally, studies could investigate the applicability of these methods in different educational contexts and disciplines to further understand their broad effectiveness. The novelty of this approach lies in its combined strategy, offering a practical solution to enhance educational outcomes in similar contexts.

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