The Influence of Laboratory Experience Timing on Student Knowledge-Level Achievement in an Undergraduate Introductory Agricultural Mechanics Course

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Abstract

Instructors often reflect upon their teaching techniques as they begin the process of constructing a course that contains both a lecture component and a laboratory experience. Often instructors are placed in a situation, due to limited resources, where laboratory activities can not coincide directly with the lecture portion of the course both in time and subject matter. Recognizing the laboratory as a time where students can apply the content knowledge presented in lecture to influence retention of information it is important to give each student the best experience possible. Noting the importance of the laboratory portion of agricultural mechanics and having limited space, equipment, and financial resources, instructors must create methods to maximize the educational impact of the laboratory experience and serve student learning. Students were grouped by prior experience in content area as well as students having completed or not completed a laboratory activity related to the lecture material at the time the lecture exam was given. Test scores were analyzed in an introductory agricultural mechanics course to evaluate possible group differences. Findings indicated no significant differences on content knowledge test scores between students who possessed prior experience versus those students who did not possess prior experience in the subject of small engines. Timing of the laboratory activity was found to have no bearing on how well students performed on the content knowledge assessment.

Introduction

According to *America's Lab Report* (National Research Council [NRC], 2006) the need and the role of the laboratory instruction has increased in the past 20 years. Driver (1995) states teacher's interventions, expectations, and actions help promote further student understanding in the laboratory setting. Quality laboratory instruction thus becomes a valuable concept in the curricula. The National Research Council (2001) states due to this growing awareness many institutions (secondary and postsecondary) have improved laboratory facilities. Smith et al. (2002) find facilities a serious problem for laboratory instruction. Developing methods which promote student learning and lab utilization is a key factor to maintaining current facilities and allowing for administration to develop new or modernize current structures (NRC, 2006).

The state of laboratory facilities and of resources to operate those facilities is of great concern in many secondary and post-secondary educational settings. In many cases, institutions have capital funds to build laboratory facilities, yet fail to adequately fund the equipment and supply needs of those facilities either due to lack of operational funds or poor administrative budgeting (NRC, 2006). Banilower et al. (2004) reported that there is great disparity in funding for laboratory facilities and supplies based on institution size and demographic composition of the students.

America's Lab Report (NRC, 2006) outlines seven goals of laboratory experiences: (1) enhance content knowledge mastery, (2) develop scientific reasoning skills, (3) develop an understanding of the complexity and ambiguity of empirical work, (4) develop practical skills, (5) understand the nature of science, (6) cultivate interest in science and interest in learning science, and (7) develop teamwork abilities. Ultimately, the goal is to move the learners' understanding from the lower levels of Bloom's Taxonomy

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(Bloom et al., 1956) to the higher levels. However, in order to reach those higher levels, a solid foundation must be laid at the knowledge level upon which further understanding can be built (Anderson and Krathwohl, 2001). Hofstein and Lunetta (2004) note there is little research which investigates when laboratory experience ought to occur in coordination with classroom lecture. The question if laboratory instruction should precede, coincide with, or follow classroom instruction remains unanswered. Compounding the pedagogical issue and implications of the timing of laboratory instruction is the more practical issue of educational laboratory facilities and supplies.

Regardless of the logistical and resource challenges of managing laboratory instruction, providing quality laboratory experiences for learners is still important (NRC, 2006). Allowing students to troubleshoot problems and develop further knowledge and understanding through investigation brings Blooms taxonomy to the synthesis and evaluation levels (Bloom et al., 1956). Diederen et al. (2006) state laboratory skills are regarded as indispensable for learning objectives and application of the reality of phenomena. "Laboratory skills cannot (or hardly) be learned outside the laboratory" (Diederen et al., 2006, p. 230). The key then to providing this important educational experience lies in the practitioner's ability to creatively balance the ideal with the practical.

Situation

In this particular situation, the class had more students than supplies. Eight small engines were available for use with all sections of agricultural mechanics. The instructor would lecture over small engine topics and one laboratory section would focus laboratory instruction on small engines. Meanwhile, other sections would be applying knowledge from topics previously discussed in class or yet to be discussed in class (electricity, construction, and surveying). Laboratory sections would be placed on a weekly rotation throughout the semester to ensure completion of all required laboratory activities. It is noteworthy that all laboratory activities were directly linked with lecture principles, but were separated by time, resources, and facilities.

The instructor at this Midwestern public university used this method for six years and was challenged each year by students who were not receiving the laboratory preparation at the time of lecture. Students perceived they were scoring lower on their knowledge level assessment than peers who were receiving the laboratory component in synchronization with lecture. This created a dilemma for the instructor as he believed students held no advantage due to the laboratory experience while being assessed on mechanical principles. Although maybe ideal, the instructor was unable to effectively provide the same laboratory experience for each laboratory section due to unavailable equipment, limited resources, and course time restraints. This limitation led to staggering topical laboratory investigations over all concepts taught during the 16-week semester. This instruction strategy was selected since the instructor did not want to compromise individual learning and create larger laboratory groups thus lowering the amount of hands-on experience for students.

Content knowledge taught in the classroom supplemented the laboratory experience that provided for investigation and analysis of skills. Students were assessed on classroom mechanical principles and laboratory experiences; making it possible to teach and assess content knowledge through classroom tests and assess laboratory through modules. Each student had access to course notes, PowerPoint slides, video clips, and a database of websites for further investigation through WebCT®. The lecture portion of the course was utilized to enforce the course notes through related class discussions and websites. The laboratory activities were directly related to course content and development of mechanical attributes.

Each student enrolled in the course had the same instructor for the lecture and laboratory portions of the course. The primary instructor and several lab assistants supervised all laboratory activities. The instructor took into consideration how he could provide students with information so they were not at an academic disadvantage by not having laboratory experience on a knowledge level exam; this led to the assessment of this type of instructional methodology.

Instructional strategies were evaluated in an introductory agricultural mechanics course. The course is a lecture-laboratory course designed to provide basic instruction on principles in small gas engines, electricity, construction, and surveying. Students receive two hours of classroom based lecture-discussion and two hours of laboratory experience each week.

Purpose and Objectives

The purpose of this study was to determine the influence of the timing of laboratory experiences has on student content knowledge-level achievement in an introductory agricultural mechanics course. The objectives of the study were as follows:

1. To determine the influence of previous experience on student content knowledge-level achievement.

2. To determine the influence of laboratory experiences on student content knowledge-level achievement.

Since the research base does not support the use of directional hypotheses, null hypotheses were used to analyze these objectives. All null hypotheses were tested at the .05 level of significance.

Ho_1: There is no significant difference in student content knowledge-level achievement of students based upon previous experience.

HO_2: There is no significant difference in student content knowledge-level achievement of students based upon completion of a laboratory exercise.

Methods

This study utilized a static-group design (Campbell and Stanley, 1963), since random assignment of subjects to treatment groups was not possible. Intact groups were used and treatments were randomly assigned to groups. The two treatments used were: (1) subject matter instruction in a lecture-discussion setting coinciding with laboratory instruction and (2) subject matter instruction only in a lecture-discussion setting with no laboratory activities prior to the lecture exam.

The target population for this study was students enrolled in a state university during the spring 2006 semester. The accessible sample consisted of an intact group of students enrolled in an introductory agricultural mechanics course (n = 69). All of the students were enrolled in the same lecture section, but then had the option to enroll in two separate laboratory sections. Usable data were obtained from all students in the sample. As a clinical study, the findings of this research are not generalizable beyond the sample.

Data were gathered by instructor developed instruments following the completion of a small engines unit of instruction. Content knowledge-level achievement was measured by assessment derived from the knowledge-level objectives of the course. Demographic data were collected via a written questionnaire.

Results

The population of this study included the 69 undergraduate students enrolled in the introduction to agricultural mechanics course. The first laboratory section which received laboratory instruction on dissembling and reassembling a small gas engine coinciding with lecture content included 34 students. Twenty-nine percent (n=10) of the students in section one were female. The second laboratory section, which did not receive laboratory instruction prior to the lecture exam, included 35 students of which 17% (n=6) were female.

Upon further investigation, no significant difference was found in final test scores based on gender (see Table 1). An independent *t* test comparing the test scores of male and female student produced a *t*-value of 0.674 ($P = .503$).

Table 1. Differences in test scores by gender

Gender	*M*	*SD*	*t*	*p*
Male ($n = 53$)	79.41	.14	.674	.503
Female ($n = 16$)	76.85	.10		

Objective one of this study sought to determine the influence of previous experience with mechanics on a knowledge level assessment. Students self-reported any prior experience with small gas engines prior to data collection. Thirty students indicated mechanics experience prior to entering the university course. It can also be noted that all students who indicated prior experience were male. Therefore, no analysis was completed investigating the influence of prior experience within gender. The null hypothesis of no differences in the knowledge level lecture based assessment based upon previous experience was used to assess this influence. An independent t test produced a t-value of 1.773 (P = .081). Therefore, the null hypothesis of no difference in the knowledge level assessment of students based upon previous experience failed to be rejected (see Table 2).

Objective two sought to determine the influence of having a laboratory experience on a knowledge level assessment. The null hypothesis of no differences in the knowledge level classroom based assessment based upon laboratory experience was tested.

Table 2. Differences in knowledge level assessment with previous experience

Experience	*M*	*SD*	*t*	*p*
Experience ($n = 30$)	82.00	.12	1.773	.081
No experience ($n = 39$)	76.37	.13		

Table 3. Differences in test scores with laboratory instruction on the knowledge level assessment

Instruction	*M*	*SD*	*t*	*p*
Laboratory instruction ($n = 34$)	78.58	.13	.147	.883
No laboratory instruction ($n = 35$)	79.05	.13		

An independent t test comparing the test scores of students who had received laboratory instruction with those student who had received only classroom (lecture) instruction revealed a t-value of .147 (P = .883). Therefore, the null hypothesis of no difference in the knowledge level assessment of students based upon receiving laboratory experience failed to be rejected (see Table 3).

Discussion/Implication

The question of how a lecture/laboratory course should be structured, especially with large course enrollments, is one faced by many in our profession. Should laboratory activities be directly coordinated with lecture content at the specific time the content is being addressed in lecture? The literature tells us that integrating laboratory instruction and lecture instruction is the ideal (NRC, 2006). However, in many cases due to limited resources instructors are not able to live in this "best case scenario." The challenge then becomes one of finding the means to accomplish the educational objectives of the instruction within the resource constraints.

One possible means to accomplish this would be to increase laboratory group size. However, this could reduce the amount of contact time an individual student has with the phenomenon under investigation. This study investigated the innovation of instituting a rotational schedule of laboratory investigation to maximize the use of limited laboratory space, equipment, and supplies.

No significant difference in knowledge level achievement was discovered based on student prior mechanics experience or when the laboratory experience occurred. Therefore, students who completed the lecture based exam prior to completing the laboratory exercises were not at an academic disadvantage compared to their counterparts who had completed the laboratory portion of the unit of instruction.

These findings in no way diminish the importance or role of laboratory instruction. Rather, according to the results of this study, instructors can vary laboratory activities with lecture content as long as they are assessed separately. Laboratory activities should still be utilized to allow students to practice or apply their newfound knowledge in a supervised environment with the goal of achieving the higher levels of Bloom's Taxonomy. Further research is needed to determine the influence of when the laboratory experience occurs on achievement of the higher levels of Bloom's Taxonomy.

As Diederen et al. (2006) stated, laboratory instruction is a critical tool in increasing a student's understanding and ability to apply knowledge. However, the reality of disparity in laboratory facilities and equipment noted by Banilower et al. (2004) often requires instructors to be creative in how laboratory instruction is delivered.

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