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ABSTRACT

This study explored the application of authentic discovery laboratory techniques in the teaching of motor learning with 35 undergraduate students. Students received either the traditional theory driven protocol during the laboratory component of a required motor learning class or were asked to complete the laboratory component utilizing "consider" questions and observation notes typical of authentic discovery style investigations. Data analysis demonstrated that students in the authentic discovery laboratory environment scored higher on laboratory report writing and, to some extent, course examinations than did students in the traditional laboratory environment. (Contains 14 references.) (DB)

Authentic Discovery Laboratories In Motor Learning

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Abstract

The purpose of this study was to explore the application of authentic discovery laboratory techniques in the teaching of motor learning. Undergraduate students received either the traditional theory driven protocol in conducting the laboratory component of required motor learning class or were asked to complete the laboratory component utilizing consider questions and observation notes typical of authentic discovery style investigations. Data analysis demonstrated that students in the authentic discovery laboratory environment scored higher on laboratory report writing and to some extent course examinations than students in the traditional laboratory environment. Discussion presents further explanation of authentic discovery techniques in motor learning.

Authentic Discovery Laboratories In Motor Learning

Motor learning, similar to other scientific disciplines, depends substantially on the use of laboratory experiences to enhance student learning. However, many of the science disciplines are aware that much of the time spent in traditionally designed laboratory classes has been "a meaningless ritual and a waste of time" (Hegarty, 1982). Often, students in traditional laboratories are led through a process of theory driven or "top-down" experimentation emphasizing a priori observations, adherence to established protocol and an abundance of teacher-student interactions. This type of traditional laboratory style suggests to the student that experimentation is a passive, mechanistic process limited by teacher-directed observation. The result is a limited generation of knowledge (Snyder, & Abernethy, 1992), low quality student-student interaction (Pizzini & Shepardson, 1992) and general lack of enthusiasm on the part of the student toward the subject matter.

Clearly the laboratory component of a science course should be designed as a rich and dynamic process that leads to the generation of knowledge. The most promising ideas for innovation in the science curricula have focused on data driven or bottom up experimentation leading to authentic student achievement (Pestel, 1992). As such, discovery laboratories are designed to be exercises in doing (Pickering, 1982), emphasizing inquiry and application vs. verification of existing theory.

Science curricula are being revised so that the discovery laboratory experience serves as the starting point in presenting course content (Pestel, 1992; American Chemical Society General Curriculum Task Force, 1992). Laboratory driven curricula are grounded in discovery learning and authentic achievement theory, in which the learner is to produce new knowledge rather than reproduce prior knowledge (Elliot, 1992). Discovery learning parallels bottom-up or data driven styles of experimentation. As new information is obtained through observation and empirical findings, hypotheses are inferred. These then serve as the basis of confirming or refuting perceived regularities and lawful relationships that generate into new knowledge (Shute, Glaser, & Raghavan, 1988; Snyder, & Abernethy, 1992). Student-student interaction increases as students share information and seek feedback on their understanding from others, all stimulated by laboratory content, not procedures (Pizzini & Shepardson, 1992).

The manner in which students interact and degree of student autonomy in the classroom, may have greater impact on achievement than curricula or teacher behavior (Hertz-Lazarowitz, Baird, Webb, & Lazarowitz, 1984; Humphreyes, Johnson, & Johnson, 1982). Cooperative learning in a problem solving context appears to promote student achievement because of shared information and resources (Johnson, Skon, & Johnson, 1980). The ideal discovery environment would allow students to develop a systematic plan for investigation of a topic of inquiry that has arisen from their involvement with the variables of interest. Based on their experience and available resources, students would select/or design the tools of investigation, as well as plan for data collection and organization of results Students would then determine if this new information confirmed or negated prior beliefs, identify discrepancies between their findings and others, then proceed to test new hypotheses and general principles based on this newly acquired knowledge (Shute, Glaser, & Raghavan, 1986). In this best case scenario, the knowledge is considered authentic as it is arrived at "through doing" and derived from observations explored through firsthand experience. The process allows the participant to challenge the real world, not just simulate it (O'Neil, 1993).

While other science curricula, e.g., chemistry and physics, have begun to address the benefits of authentic discovery learning (Pestel, 1992), its suitability in the area of motor learning has yet to be explored. The purpose of the present study was to examine the effectiveness of incorporating one aspect of the authentic discovery laboratory style to a traditional motor learning laboratory environment. Specifically, would the use of authentic discovery techniques (consider questions and observation notes) increase student knowledge as compared to that of a traditional theory driven laboratory experience in a university undergraduate motor learning course. A comparison was also made of the effectiveness of the different laboratory conditions to influence student interest and satisfaction as reported in a subjective course evaluation.

Subjects

An intact sample population of students (n = 35) enrolled in a required upper level undergraduate motor learning university course was utilized in the study. All students attended a common lecture for two hours per week and registered for an additional laboratory hour during one of two scheduled times. Registration into the laboratory sections was solely based on student availability for the scheduled times.

Method and Procedure

One laboratory section was assigned the control condition, the traditional laboratory protocol, the other section the experimental condition of authentic discovery style laboratory procedures. The traditional or control laboratory condition required students to read a prepared handout on assigned experimental procedures as they entered the lab. Instructions were specific to collecting and recording data during the laboratory assignment. In order to protect the validity of the independent variable under analysis, students received partial or varied instructions depending on whether they were to be subjects or investigators . Each student was encouraged to complete the data collection and recording independently of other students so that the entire class could complete the assignment in the specified time.

In the authentic discovery laboratory condition, students received the identical laboratory procedure information as the control group, but were asked to involve two additional processes in conducting their research. First, the students were asked to read and respond to prepared "consider questions" prior to and during data collection. The "consider questions" were designed to stimulate observation and inquiry during data collection (See Table 1). The design and sequence of "consider questions" were modeled after those used in a physics course at another university (Pestel, personal correspondence). The nature of the "consider questions" is to engage the student in an interactive process with the experimental variables. Students were asked to hypothesize about the influence of subject or the environmental factors, experimental task demands, or possibly the nature of the data prior to the prescribed formal analysis. In some cases, consider questions posed inquiry as to the application of the experimental concept.

Secondly, students were encouraged to make observation notes as they collected the data. "Observation notes" were to be anything the student felt worthy of notation regarding experimental conditions, confounding variables, or predicted results that could be shared with other students or used at a later time for greater understanding of the experimental concept. These observations were to be independent of the prescribed data recorded for completion of the class assignment. For example students might record verbal comments made by a subject about the difficulty of a choice reaction time task, or an hypothesis that a particular subject might be doing well on a balance task because of a previously demonstrated physical ability, or even a note to find out what the pursuit rotor has been used for in other research. The observations were not collected for formal evaluation but the recording of the field notes were informally reinforced by the laboratory supervisor. Students were also encouraged to talk and share their observations with other students as they made their observation notes, regardless of their role as subject or investigator during the experimental process.

Both laboratory sections conducted the same seven laboratory assignments and received the same lecture prior to and after the laboratory experience. All examinations and class evaluations were administered and graded by the lecture instructor. The laboratory content and evaluation criteria were prescribed by the lecture instructor, while the laboratory reports and consider questions were evaluated by a different instructor supervising the laboratories. Students were not informed of the research design or that the two laboratory sections were being treated differently until after final examinations and evaluations were conducted.

Independent and Dependent Variables

Effectiveness of the two laboratory conditions was assessed by examining differences in student knowledge as measured by overall percentage of correct responses on written examinations and laboratory reports. Three equally weighted essay format examinations were summed to generate the total percent score. Students were given eight laboratory assignments from which they could drop the lowest score in tabulating the final percentage. The laboratory report asked students to utilize a standardized format that included: identification of dependent and independent variables; graphical analysis of data; presentation and application of results in a meaningful discussion; and drawing appropriate conclusions.

Influence of the laboratory condition was also assessed by comparison of self-reported student satisfaction and interest in course content. Students responded on a four-point Likert-type scale to eight questions modified from the university student course evaluation instrument. A total of the responses to the eight questions was utilized in the analysis.

Results

A multiple analysis of variance was conducted on the three dependent variables (written exam totals, laboratory report totals, and student evaluation total) and independent variable of laboratory condition (traditional vs. discovery). The analysis indicated no significant difference ($F = 1.466$, $df = 24$, $p = .252$) between the two laboratory conditions on the three dependent variables. Since the purpose of this study was exploratory in nature, further analysis was conducted to detect any trends for subsequent study.

A follow-up analysis of variance did reveal that students in the discovery laboratory section did significantly better on laboratory reports ($F = 4.471$, $df = 34$, $p = .042$) than students in the traditional laboratory section. There was a positive trend, although not statistically significant ($F = 3.422$, $df = 34$, $p = .0725$) , in differences in written examinations between the two sections. Students receiving the authentic discovery techniques scored a mean total of 23 points (10%) higher on their written examinations than students in the traditional theory driven laboratories (See Table 2).

Student evaluation of course satisfaction and interest ($F = .076$, $df = 24$, $p = .785$) did not seem to have been influenced by the laboratory settings. Both laboratory sections seemed to feel they understood what to do during the data collection process and that the laboratory experiences were a slight help in understanding course concepts.

Discussion

There was some promising trends reflected in specific student outcomes as a result of using authentic discovery over that of traditional theory driven laboratory settings. While the overall analysis suggests no statistically significant difference in student learning, the utilization of authentic discovery techniques in motor learning experimentation did improve the effectiveness of the laboratory component to aid in understanding course content as reflected in the laboratory reports and to some extent written exams. A number of factors should be considered in reviewing the results of this exploratory study.

First, in order to isolate the effect of the discovery techniques under investigation, there was no attempt to manipulate the structure or mechanisms of the lecture component of the course. An ideal authentic discovery format would have even greater student-initiated procedures and control than used in the present study. Newmann (1991) suggests that at least four classroom conditions are necessary for authentic achievement to occur: "collaboration, access to tools and resources, worker discretion or opportunity for ownership, and flexible use of time," p. 460. The consider questions and observation notes may have encouraged students to engage in a minimal amount of collaboration, but not enough to generalize to understanding of overall course content.

Pizzini and Shepardson (1992) demonstrated through structured observations and path analysis a difference between the classroom dynamics of a traditional laboratory model and a problem-solving design. In the problem-solving laboratory model, student behaviors were geared to the goals of the lesson and lesson structure (solving the problem), rather than focused on teacher-student interactions that provided clarification of instructions. Students in the problem-solving classroom experiences were more involved in their learning, by sharing ideas with other students and providing explanations to questions. In the present study, laboratory content coincided with lecture material, however the laboratories themselves were not used as the base for discussion during classroom lectures. In fact there was little student interaction during classroom lectures.

Second, the use of traditional essay or short-answer examinations as the dependent variable in the present study reflects traditional curriculum-based assessment procedures which may be perceived as inconsistent with the spirit of an authentic achievement paradigm. Authentic assessment procedures should reflect the student's ability to demonstrate worth-while, significant, and meaningful tasks in a production rather than reproduction format (Archbald, 1991; Elliott, 1991). Results would be more likely confirmed through laboratory reports since report writing reflects assessment closer to that depicting authentic achievement. Laboratory reports require the integration of knowledge and experiences in production of a scholarly work. The lack of significant differences in the written exam scores may be reflective of the assessment content rather than lack of impact on student achievement.

It was surprising that students in the authentic discovery setting in the present study were no more satisfied or confident in regard to understanding than the traditional theory driven setting. The use of discovery techniques in previous studies seemed to generate a high degree of perceived self-control by students which in turn improved student satisfaction and confidence (Hertz-Lazarowitz et al., 1984; Johnson, Skon, & Johnson, 1980; Shute, Glaser, & Raghavan, 1988). When students are given opportunities to control the pace and direction of their learning the conditions are set for authentic achievement. However, the use of two different instructors in laboratory evaluations and core classroom management might have weakened the generalization between these two course components.

The full potential of a laboratory-driven curricula and pursuit of authentic achievement in motor learning has yet to be determined. Future research should be directed at determining how authentic discovery influences individual rate of learning as well as its application to different content areas within the motor learning discipline. Results of this study indicate the potential of authentic discovery laboratories in advancing student learning. Specifically, the traditional theory-driven experimental process was modified to encourage students to become more interactive in the experimental process by considering influencing variables, noting and then sharing observed discoveries throughout the data collection process. Results would support the notion that classroom dynamics that encourage inquiry and heighten the quality of student-student interaction will improve learning.

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Table 1. Sample "consider" questions for each laboratory assignment.

Laboratory Topic	Consider Question
Reaction time	What, if any, characteristics of the subject might affect the observed reaction or movement time?.
Closed vs Open Loop Motor Control	What do you think would happen to the percent of time on balance if the time trial was 60 seconds instead of 30 seconds?
Motor Programs	What type, if any, of errors in movement did the subject make in completing the different motor tasks?
Speed vs. Accuracy	How many times do you think you will be able to tap the correct target considering the different stimulus conditions? Why?
Learning Curves	Before beginning collection of data, how will you determine if the subject has "learned" the motor task routine?
Mental Practice	Have you ever done this motor task before? Does it resemble any other motor tasks you are familiar with? How do you think you will do?
Transfer of Learning	What type of motor task are you being asked to perform?

Table 2 Descriptive statistics for dependent variables by traditional and authentic discovery laboratory conditions.

	Laboratory Conditions			
	Authentic Discovery		Traditional	
Dependent Variables	Mean	SD	Mean	SD
Laboratory Reports	83.000	12.638	70.3	20.479
Written Examinations	217.467	32.167	194.0	40.243
Subjective Evaluation	25.267	4.183	24.8	4.104