Computer Assisted Fluid Power Instruction: A Comparison of Hands-On and Computer-Simulated Laboratory Experiences for Post-Secondary Students.

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Introduction

Despite demand from industry, there has been a general lack of emphasis placed upon course content in fluid power by post-secondary educational institutions in this country. The cost of development for the required laboratory facilities is often cited as a major obstacle to fluid power content development.

There is considerable recent research on the use of computer assisted instruction and computer simulation for technical training. Some of the areas that have been studied include the teaching of subjects such as: Electricity and magnetism (Chou, 1998), electrical operational amplifiers (Dobson & Hill, 1995), basic electronics (Moslehpour, 1993), engineering fluid mechanics (Engel et al., 1996), basic thermodynamics (Buttles, 1992), chemistry (Grosso, 1994), engineering physics (Chien, 1997), military pilot training (Andrews et al., 1996).

Much of this research has also been tied to individual differences in cognitive learning styles. In a 1994 review of literature, Moldafsky and Kown reported that cognitive learning style can be responsible for a person's lack of ability to process information from computers, along with their attitude and anxiety towards computers. Additional studies found that individuals with certain cognitive styles could significantly out perform others when asked to recall material presented using computer-based instruction (Hsu, Federick & Chung, 1994; Burger, 1985). There has also been considerable research to link cognitive learning style to a student's choice of a major and achievement within that major (Witkin, 1973; Witkin et al.,1977a; Gregorc, 1979; Garger & Guild, 1984; Torres & Canno, 1994; Garton et al., 1999).

The fluid power industry has had difficulty in achieving the professionalism and formal educational system found in many other engineering and technical fields. The high cost of training equipment may contribute to this problem (Luzerne County Community College, 1987). The small amount of available literature pertaining to fluid power education is a strong indication of the lack of emphasis that this subject area has historically received.

The literature review also indicated that a selection of fluid power computerized design and simulation software is now available. Various software programs can be used to perform computer aided design and testing of circuitry, or even complex engineering analysis of dynamic systems and component selection. Computerized simulations used for instruction can assist the student in developing mental models of many different types of complex systems (Mayer, 1989; Mayer & Sims, 1994; Munro & Towne, 1992; Perkins & Unger, 1994). There is a gap in the literature in terms of the application of computerized simulation to train people for the fluid power industry, which could result in a large reduction in the implementation costs of such a program. The certification levels offered by the Fluid Power Society (FPS) have brought the industry some much needed industry recognition. It is time for the educational community to focus on the need to offer courses in fluid power on a more consistent basis.

Purpose

The primary purpose of this study was to examine the effectiveness of utilizing a combination of lecture and computer resources to train personnel to assume roles as hydraulic system technicians and specialists in the fluid power industry. This study compared computer simulated laboratory instruction to traditional hands-on laboratory instruction, in terms of effectiveness.

Method

This study used a within-subjects repeated measures design to determine the relationship between two methods of teaching fluid power laboratory experiences and student achievement on a cognitive written instrument, as well as a performance (psychomotor) instrument. As secondary research areas, the study examined the relationship of cognitive learning style (field-dependant or field-independent), as well as the sequencing of the laboratory assignments, to the level of student achievement on a performance (psychomotor) instrument.

Four sections of the same college course, with a total of 70 subjects, participated in this study. After receiving the same lecture at the same time, the subjects in each course were randomly split into two treatment groups. Group B completed the first two laboratory assignments using the traditional hands-on fluid power trainers, while Group A completed the first two laboratory assignments using the computerized fluid power simulation program. Upon completion of the first two laboratory assignments, the performance instrument was individually administered to each student.

The performance (psychomotor) evaluations were given using a criterion- referenced instrument at the completion of the first two laboratory assignments and prior to switching to the other type of trainer. The student could receive a score of zero to three points on the performance evaluation, with one point awarded for each of the three required tasks which were completed correctly within the 15 minute time limit.

Upon completion of the mid-lab performance test, each of the groups switched to the other type of laboratory trainer so that all of the students experienced both the hands-on trainers and the computerized simulation program. Upon completion of both treatments, the performance (psychomotor) test was re-administered to each subject individually. At the completion of the course, the Group Embedded Figures Test (GEFT) was administered to all of the students to determine the cognitive learning styles (field-dependant or field-independent) of each subject.

Separate t-test procedures were used to determine differences in actual student performance between the two treatments, as well as to examine the relationship between learning styles (high or low GEFT scores) and performance scores between the treatment types. Additional t-tests were conducted to determine if the sequencing of the treatments resulted in differentiated student performance as well as to determine if there was a relationship between student final performance scores and learning styles (high or low GEFT scores). A paired t-test was conducted to determine if there was a significant difference between mid and post performance test scores and the sequencing of the treatment types. The last statistical analysis involved using another t-test to determine if there was a significant difference between the sum of the two unit exam scores and the sequencing of the treatments.

Findings

The findings of the study which are of value to educators are as follows;

1. There was not a statistically significant difference between the performance of the two treatment groups on the psychomotor instrument after the completion of the first two laboratory assignments.
2. The subjects classified as field-independent learners scored statistically significantly higher on the mid-lab psychomotor performance test than did the field-dependent learners.
3. There was not a statistically significant difference in student performance on the post-lab psychomotor performance evaluation as a result of the sequencing of the treatment types between the two groups.
4. The subjects classified as field-independent learners scored statistically significantly higher on the end-of-lab psychomotor performance test than did the field-dependent learners.
5. The difference between the mid- and post- psychomotor test scores within each group as a result of the two different methods of treatment sequencing was not statistically significant.

Table 1: The Research Design

	Treatments:	
Groups:	**1st & 2nd Lab Assignments:**	**3rd & 4th Lab Assignments:**
Group A	Treatment I: Computer-Simulation Labs	Treatment II: Hands-on Trainer Labs
Group B	Treatment II: Hands-on Trainer Labs	Treatment I: Computer Simulation Labs

6. There was a statistically significant difference in the sum of the cognitive unit exam scores between the subjects in the two different treatment groups. Treatment Group B, which completed the hands-on exercises before completing the computer simulation exercises, had a higher mean score.

Conclusions

The conclusions from this study may be generalized to the population from which the sample was drawn. This study examined the use of computerized simulation for teaching basic fluid power circuitry, and not its use as a tool for engineering analysis of hydraulic or pneumatic systems. Specific conclusions of value to educators are as follows;

1. Similar results can be achieved on a psychomotor performance evaluation whether the instruction is given using a computerized simulation program or a traditional hands-on trainer to teach basic fluid power circuitry.
2. Where both computerized simulation and hands-on trainers are used for fluid power instruction, the sequencing of the two types of laboratory instruction results in similar student psychomotor performance.
3. Students classified as field-independent learners perform better on psychomotor performance tests on basic fluid power circuitry than those classified as field-dependent learners.

Discussion

The finding that similar results can be obtained on a hands-on psychomotor evaluation using computerized as compared to hands-on laboratory instruction is contrary to conventional educational practice in the specific field of fluid power. While computerized laboratory instruction may never replace traditional hands-on laboratory instruction, it could offer similar student performance results where financial or physical constraints prevent the purchase and use of hands-on fluid power trainers. The potential impact of this finding could include an increase in the number of colleges and universities who are able to afford to develop and offer courses in basic fluid power by utilizing existing computer laboratories. In addition, the greater portability of lap-top computers when compared to hands-on fluid power trainers (which often weigh several hundred pounds and cost several thousand dollars each), could encourage more on-site fluid power courses to be offered away from the main campus. Through the use of a server to allow student access to the simulation program, it may be practical to offer a fluid power course in a distance-leaning format.

The lack of difference in performance on the end-of-lab psychomotor test of the two groups indicates there is no difference in the sequencing of the hands-on and computerized stimulation laboratory instruction. However, this study only examined a 50% to 50% split of the two types of laboratory instruction.

Subjects classified as field-independent (FI) learners did achieve a statistically significant higher score on the mid- and post-psychomotor test than did the field-dependent (FD) learners. An earlier study found that field independent (FI) learners were better able to mentally restructure information than field dependent (FD) learners (Wilkin et al., 1977). In addition, FI learners were found to be better able to recall material presented using computer based instruction (Hsu et al., 1994; Burger, 1985). This finding may also have implications for the level of degree that a technical student is seeking. A 1995 study by Hansen determined that the learning styles of four-year post-secondary technology students were more field independent than their two-year counterparts.

This study also found that treatment Group B, which completed the hands-on exercises before the computer simulation, attained a higher mean score on the sum of the unit exams as well as each unit exam separately. However, as the first unit exam was given before the treatments began and the second unit exam was given after the treatments were finished, the impact of the significant difference of the sequencing of laboratory assignments on the outcome of this study is minimal.

Applications for two and four year post-secondary technical programs

While traditional-hands on training will likely still continue to be the preferred method of conducting fluid power instruction, this study has shown that satisfactory results can be achieved using a computerized simulation program. It should be pointed out that unlike a computer-aided design program, a simulation program allows the student to see the system operate, and thus verify, the control logic of the circuit. This study utilized the Automation Studio software package from FAMIC Technologies, (www.automationstudio.com). In addition, supporting fluid power training material can be extremely helpful when explaining fluid power operational principles. A partial listing of sources of fluid power training materials includes: the International Fluid Power Society (www.ifps.org), National Fluid Power Association (www.nfpa.com), Eaton-Vickers Corporation (https://web.fluidpower.eaton.com), Rexroth Hydraulics (www.boschrexroth.com) and Parker-Hannifin (www.parker.com/training).

Basic fluid power trainers can cost from $10,000 for a Vickers unit to almost $15,000 for a Parker unit. Typically two students can use one of these trainers at the same time, producing an equipment cost of $5,000 to $7,500 per student. The cost of developing a computerized simulation lab for fluid power instruction is normally much lower. A six copy package of the Automation Studio software is priced at approximately $650 per copy, which combined with an average price of $1000 to $1200 for a computer package yields a cost of approximately $1600 to $1800 per work station. If two students are paired up on each computer station the equipment and software costs can drop to $800 to $900 per student. Thus, developing a fluid power instructional laboratory can be accomplished at approximately 1/3 to 1/6 of the per student cost of developing a similar sized lab using traditional hands-on fluid power trainers.

While professionals in the fluid power field often express a concern for the loss of hands-on skills when computers are used to teach laboratory applications, a blend of hands-on and computerized-simulation based training for fluid power instruction seems to be the best alternative. When available, a basic hands-on fluid power trainer can be a very valuable tool to teach the basic circuitry and troubleshooting. Complex fluid power circuitry can often be more easily taught using a simulation program. While the Automation Studio package does include detailed drawings of hydraulic components, actual cutaways of the various valves, pumps and motors prove to be an excellent teaching tool as well. Fluid power component cutaways are available from the training departments of the corporations listed above. In situations where the funds for a full complement of hands-on fluid power trainers are not available, computerized simulation packages can provide a low-cost alternative while still being able to offer this important educational opportunity to our students.

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