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An experimental approach to class lecture and demonstration techniques in teaching industrial arts

Frank Henry Jolly
Iowa State University
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AN EXPERIMENTAL APPROACH
TO CLASS LECTURE AND DEMONSTRATION TECHNIQUES
IN TEACHING INDUSTRIAL ARTS

by

Frank Henry Jolly

A Dissertation Submitted to the Graduate Faculty in Partial Fulfillment of The Requirements for the Degree of DOCTOR OF PHILOSOPHY

Major Subject: Industrial Education

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

Head of Major Area

Signature was redacted for privacy.

Dean of Graduate College

Iowa State University
Of Science and Technology
Ames, Iowa
1970
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INTRODUCTION

Education, if it is to improve at a pace that is consistent with that of the technological field, must carry on a continual search for more effective and efficient means of presenting information to pupils.

This study is an attempt to improve concept formation for industrial arts students. The specific medium used is the overhead projector. By improving the capability of the projector to demonstrate movement and operation as well as physical layout, the projector conceivably can become a more useful tool to use when expressing an idea or a concept to the student.

If this can be done effectively, it is conceivable to combine all the best features of the overhead projector with those of the single concept film loop and still to maintain the infinite flexibility of the lecture method.

The overhead projector, by showing sectional view transparencies of machines, has been used for several years as a convenient method of teaching machine concepts. It is possible to construct three-dimensional transparent working models of many machines. Pumps and other simple hydraulic components can be constructed, each of which have the characteristics and capabilities of the original.

By using such transparent devices it is possible to duplicate the performance of the original device and permit the
student to see what is actually happening to the fluid and the components. The ability to progress at the student's speed and to respond to any student's questions or misunderstandings is maintained.

Purpose

The objectives of this study were to design, build, and test a group of functioning teaching devices to investigate their capability to improve concept formation in the area of hydraulics for industrial arts students.

The method of investigation used was a comparison of teaching methods. The new material was used as the basis for a series of lectures using the overhead projector. The results with these materials were compared with the results achieved with the more traditional method where plastic film transparencies are used on the overhead projector.

The functioning teaching devices were designed to represent hydraulic concepts as they occur in hydraulic machines. They were to illustrate these concepts in a concise and easily understood way. These devices were designed for projection by the overhead projector (Figures 1 and 2) to facilitate presentation of material to large groups of students.

The development of these devices was to proceed to the point where they would function repeatedly with conciseness, reliability, and with minimal effort on the part of the instructor.
Figure 1. Overhead projection of the twin gear pump

This functioning teaching device was projected on a wide angle Bell and Howell overhead projector. The screen was approximately 4' x 4'.

The specks dispersed through the water were the projections of black pepper used to monitor fluid movement. The small clusters of specks which show up between the gear teeth around the outside of the gears illustrate the fluid movement through the pump itself.

The ring-shaped channel was a passage representing the external circuit of which the pump was a part.

Figure 2. Overhead projection of a planetary gear set

The projector and screen are identical with those used for Figure 1.

This unit was used in the study as a pre-experiment training aid. See Figure 3. It was used to illustrate the seven different gear ratios and resulting torque conversions possible with a planetary gear set.

The total group of teaching devices used in the pre-experiment training lecture are illustrated in Figure 3.
A pre-experiment torque conversion demonstration and lecture were given to both control and experimental groups. This was done to remove any advantage that any student might have had from any previous experience in mechanics. Mechanical gear trains, torque conversion, and planetary gear sets were covered. The four units illustrated here are the hardware which were designed for this purpose. For a projection of the planetary gear set, see Figure 2.
Scope

Twenty-five basic concept areas of hydraulics were chosen. Those used in this study were fluid pumps, fluid motors, accumulators, control valves, flow controls, actuators, and finally four basic hydraulic circuits.

Each type of pump or other unit was developed as a standard transparency, then built as a transparent functioning teaching device.

The sample was 120 eighth grade industrial arts students at Merrill Junior High School, Des Moines, Iowa. They were divided into two groups of approximately equal size. These boys were randomly assigned by classes to a control group of three classes and an experimental group of three classes.

Teaching Design

Both groups were given a two-part pretest.

Then the control group was taught each of the concepts using the standard plastic transparency method. The experimental group was given a quick introduction with the standard transparency; but then was shown each concept as it worked on an actually functioning teaching device.

In both groups every question asked by any student was answered completely and as concisely as could be accomplished
with the medium being used in his specific group.

In the control classes the transparencies were presented in combinations or systems to mock up hydraulic circuits. In the experimental group, the hydraulic parts were actually assembled into fluid-filled circuits. In these experimental circuits, the pumps were controlled by the valves which in turn controlled the actuators. During this time the fluid movement was illustrated by the projection of entrained air bubbles, fluid ripples, or an introduced medium such as black pepper. See Figure 1.

The results of the study were judged with the use of a posttest given at the end of the two weeks teaching period. Both groups were given the same test, identical to the pretest. Approximately three months after the completion of the experiment, the students were reassembled and given the same test as a retention test.

Null Hypotheses

The statistical experiment was designed to test the following null hypotheses.

1. There is no significant difference between the achievement of a control group using standard transparencies and an experimental group using functioning teaching devices.

2. There is no significant difference between the achievement of low IQ students and high IQ students within the
experimental group using functioning teaching devices.

3. There is no significant difference between the retention of a control group taught with standard transparencies and an experimental group taught with functioning teaching devices.

4. There is no significant difference between the retention of low IQ students and high IQ students within the experimental group using functioning teaching devices.

Definitions

**Standard transparency, overhead or plastic film transparency**

A plastic film transparency developed for projection on the overhead projector; can be hand-drawn or produced by machine (diazo, etc.)

**Static transparency**

A transparency usually made of plastic film, but definitely containing no moving parts

**Standard transparency with overlays**

Two or more plastic film transparencies constructed in a manner that allows one to lay directly over the other

**Animated transparency**

A projection device with one or more moving parts

**Moving parts device**

One of a group of animated transparencies; used by 3M Company to denote the total range of their devices
Functioning teaching device

A subgroup of the animated teaching devices; they are called functioning because they respond in a natural way to an external force or impart an internal force to a second medium. This is the group which was designed and constructed for use in this experiment.
REVIEW OF LITERATURE

Large numbers of studies in the general field of audiovisual material have been conducted. This research has covered the relative effectiveness of television, films, and other materials. Kemp (8) in the text, Planning and Producing Audiovisual Materials, states:

"Much research has been conducted about audiovisual materials. A large portion of the studies concerns utilization practices and proof of the instructional value of specific materials as compared with traditional teaching methods. In a smaller number of experiments a particular aspect of an audiovisual presentation was varied in order to determine the effect on learning of that particular variable. Results of the latter group have relevancy for the planning and subsequent production of audiovisual materials." (8, p. 15)

The overhead projector has been an example of a device whose use has grown slowly but steadily. As teachers have become more aware of the strengths and limitations, the amount and quality of its use have increased.

Since its inception, the construction of the material projected from its stage has evolved through several distinct steps.

Originally the overhead projector was used to replace or supplement the chalkboard. As a result, writing or printing (usually black on clear background) was the general kind of presentation offered.

Gallantine (7) evaluated the effectiveness of the overhead projector compared to the use of the chalkboard. This
comparison was made for both large and small lecture groups. The conclusion reached in his study was that there was no significant difference between the chalkboard and the overhead projector when comparing group achievement.

The first improvement in transparencies was the addition of color and shading. Pictures and maps were produced. The single sheet transparency was supplemented with overlays. These overlays could show a change in placement or position.

Shadow casting, where the dark outline of actual parts (such as tools or other small devices) is projected, has also come into rather wide use. This technique is also used by the natural sciences where leaves, rocks, or other natural objects are projected in living color on the screen.

The search for movement and realism has continued unchecked. This search brought about the introduction of the polarized projection film where movement could be mocked or simulated. (8)

This simulation naturally introduced the next phase where moving parts devices were developed.

Minnesota Mining and Manufacturing Company (commonly known as 3M) has so far dominated the field in this regard. 3M has seven moving parts devices in a current catalog. (14) These devices include a kit for magnetic field illustrations, a probability device, an abacus, a transparent slide rule, an adjustable thermometer, a two-stroke engine, and a four-stroke
A study by Silverman (12) is very closely related to the objective of this study. He compared two basic types of transparencies, static and animated. The comparison was designed to find if a significant achievement advantage could be found between the two types of transparencies when teaching basic facts about three types of firearms to 150 male college students.

The results were further divided into two types of skills. The first was mental understanding as measured by a written test; the second was physical or manipulative and was measured by a performance test.

He found no significant achievement advantage for either type of transparency on the written test, but did find a significant difference favoring the animated transparencies when manipulative tests were involved. This advantage was related to the number of simultaneously moving parts. The greater the number of simultaneously moving parts, the greater the advantage for the animated transparency.

The last stage of development in transparencies at the present time includes the functioning teaching devices. These devices are called functioning because they respond in a natural way to an external force, or impart an internal force to a second medium.

Here again 3M is represented. They have a transparent electrical meter which will respond to and actually measure an
electrical circuit. (14)

All of the devices tested in this study are in this final stage. The pumps move fluid; the valves and other devices respond to an external fluid pressure. In fact, during this study the monitoring done on existing system pressures was facilitated by a transparent hydraulic gage which functions similarly to 3M's electrical meter.

Because of the relative newness, and the small number of functioning teaching devices which are commercially available, no research directly bearing on the value of their use is available.

In the field of overhead projection, many studies have been conducted using plastic film transparencies. These studies have tried to gage the relative merits of variations in terms of format design, method of presentation, sequence of presentation, color vs. noncolor, and positive vs. negative backgrounds.

Some studies have dealt with small detail changes in format design. A study by Adams, Rosemier, and Sleeman (1) based its data on changes in readable letter size for transparencies. They found that the letter size and shape they could use was controlled by viewing distance from the screen. In fact the elite and pica size letters should be avoided entirely, and a letter of 6/32\" in size should be used for viewing distances of 30 ft. or more.
Pearce (10) compared several different types of transparency construction. He constructed 119 different transparencies using the diazo process. These were broken down into 12 categories which were:

"1. Basic transparency with hinged overlays, colored images, and a positive background.

"2. Basic transparency with hinged overlays, colored images, and a negative background.

"3. Basic transparency with hinged overlays, noncolored images, and a positive background.

"4. Basic transparency with hinged overlays, noncolored images, and a negative background.

"5. Series of transparencies, colored images, and positive backgrounds.


"7. Series of transparencies, noncolored images, and positive backgrounds.

"8. Series of transparencies, noncolored images, and negative backgrounds.

"9. Composite transparency, colored images, and a positive background.

"10. Composite transparency, colored images, and a negative background.

"11. Composite transparency, noncolored images, and a positive background.

"12. Composite transparency, noncolored images, and a negative background." (10, p. 66-67)

Pearce reached several conclusions in his study. His results when comparing sequence and non-sequence presentations were:
"This study does not lend support to the assumption that sequencing of information for concept learning is superior to presenting the information as one complete whole." (10, p. 70)

This conclusion had direct bearing on the present study; for a basic objective of a functioning teaching device was to present a concept completely in one motion in a very short time.

In regard to color, Pearce concluded:

"Noncolored images produced more learning in terms of achievement than did colored images on transparencies." (10, p. 70)

Other studies stressed the wide range of subject matter that could be covered by using the overhead projector.

Crosby (6) conducted a feasibility study where his objective was to determine if the overhead projector could be adapted to Technical Education. His conclusions were that the projector increased student interest and:

"...there is no room for doubt that the visualizing power of the overhead projector increases the depth of learning and considerably decreases the time required to cover a given area of subject matter." (6, p. 275)

Schultz (11) in the book, The Teacher and the Overhead Projector, states that the range of material in Industrial Arts which can be effectively covered with the overhead projector knows no limit.

In summary, Bendixon (2) in his dissertation states:

"Research reviewed appears to indicate that no teaching method yet devised has replaced the teacher's personality and his way of delivering the material"
sought by the student. An aid to this delivery, and perhaps the best yet conceived, may be the overhead projector. While little research has been done in vocational agriculture in relation to the effectiveness of projected transparencies on instruction, the review of literature indicates that overhead projection enables the teacher to present more technical information in a more meaningful manner, in less time and with greater thoroughness." (2, p. 21)
This chapter contains the cross-sectional drawings, specifications, and photographs of 11 of the basic hydraulic units, or functioning teaching devices.

In each case the cross-sectional drawing and the overhead transparency are identical. The designs for the overhead transparencies were based on a standardized set of transparencies used in an NDEA summer institute. The only variation between the drawings and the functioning teaching devices is in the third dimension, that is, the thickness.

Forty-five functioning teaching devices for hydraulics have been built; 16 were used for this study, but only 11 are drawn in this paper. Several improved models of each of these units have come into being largely from student comments during the experiment.

These 11 functioning teaching devices provided the basic data of the study. The last 33 questions of the pretest, post-test, and retention test were based upon the inner workings or functioning of these teaching devices.

The photographs of each device were taken using 1" square drafting paper as the background. This was done to facilitate part size and relationship which are necessary to reproduce the units. Two photographs show disassembled units to illustrate
the relative simplicity of the total design. See Figures 11 and 12.

All parts, unless otherwise indicated, are made of clear Plexiglas sheet, tubing, or rod.
Pumps

Unit 1. Cup piston pump

This unit has a main cylinder, 1\(\frac{1}{2}\)" inside diameter, and two spring-loaded check valves.

The per stroke displacement is 1/2 cup, and the working pressure is 75 PSI.

**Bill of materials**

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<thead>
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<th>Size</th>
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<td>1</td>
<td>1&quot; Plexiglas sheet</td>
</tr>
<tr>
<td>2</td>
<td>3/4&quot; Plexiglas rod</td>
</tr>
<tr>
<td>2</td>
<td>2(\frac{3}{4})&quot; Plexiglas rod</td>
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<td>1</td>
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<td>1</td>
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<td>1(\frac{1}{2})&quot; hydraulic wheel cylinder boots</td>
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<tr>
<td></td>
<td>plastic cement</td>
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Plate 1. Cup piston pump
Figure 4. Cup piston pump
Unit 2. Displacer piston pump

This pump has a relatively high pressure design. This unit can be used as a pump, a weight-loaded accumulator, or a mechanically-loaded accumulator. (Figure 5)

To transform from a pump into a spring- or mechanically-loaded accumulator, two 1" strips from an auto inner tube were stretched around the unit to depress the plunger. The resulting device was used to store energy in the stretched bands. The piston transfers the push of the rubber into fluid pressure with a resulting accumulator capability. (Figure 6)

Bill of materials

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<td>2&quot; Plexiglas rod</td>
<td>2&quot;</td>
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Plate 2. Displacer piston pump
Figure 5. Displacer piston

Figure 6. Accumulator conversion for the displacer piston.
Unit 3. Four vane constant displacement pump

This pump has a displacement of 4 tablespoons of fluid per revolution at approximately 4 PSI pressure at 10 RPM. This device is used mainly as a demonstrator and not as a power source.

Figure 7 shows the pump actually used for the experiment.

The bill of materials and the drawing are for an improved model. The changes in this pump occurred from changes suggested by students in the experimental group during the lecture.

Bill of materials

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1&quot; Plexiglas sheet</td>
<td>5&quot; x 5&quot;</td>
</tr>
<tr>
<td>4</td>
<td>1/4&quot; Plexiglas sheet (filed to suit for vanes)</td>
<td>3/4&quot; x 3/4&quot;</td>
</tr>
<tr>
<td>1</td>
<td>3/4&quot; Plexiglas sheet for rotor</td>
<td>2 1/2&quot; x 2 1/2&quot;</td>
</tr>
<tr>
<td>1</td>
<td>1/2&quot; Plexiglas sheet for cover plate</td>
<td>5&quot; x 5&quot;</td>
</tr>
<tr>
<td>1</td>
<td>1/2&quot; Plexiglas rod for shaft</td>
<td>3&quot;</td>
</tr>
<tr>
<td>2</td>
<td>1/2&quot; OD copper tubing</td>
<td>2&quot;</td>
</tr>
<tr>
<td>1</td>
<td>1/16&quot; brazing rod, bent to shape to spring out vanes</td>
<td>4 1/2&quot;</td>
</tr>
<tr>
<td></td>
<td>plastic cement</td>
<td></td>
</tr>
</tbody>
</table>
Plate 3. 4-vane constant displacement pump
Figure 7. Vane pump
Unit 4. Four lobe G-rotor pump

The theory of operation for this pump is one of the most difficult to explain. This working model when projected by the overhead projector is an extremely helpful device.

This device was made by casting a pattern from an actual oil pump. The fluid passes through a hole made by removing half the material in the indentations of the outer shell.

The bill of materials and drawing are for a better and later design than the unit pictured in Figure 8.

Bill of materials

No. Size
1 1" Plexiglas sheet 4" x 5"
1 cast copy of the rotor and shell from a G-rotor style oil pump; these units are easy to cast, but are extremely difficult to make by hand; trim these units to 1"
1 1" Plexiglas sheet 4" x 5"
2 1" OD copper tubing 2"
plastic cement
Plate 4. 4-lobe G-rotor pump
Figure 8. G-rotor pump
Unit 5. Twin gear pump

The open design pump (Figure 9) was used as a demonstrator only. Here the water was poured into the top and liberally sprinkled with black pepper. These pepper specks show up very nicely when projected upon a screen (Figure 1), and they show in concise detail the flow of the fluid through the pump. This detail includes the whirlpools and all.

Bill of materials

<table>
<thead>
<tr>
<th>No.</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>gears from Junior Turn-A-Gear toy (available at $1.04 from any toy store; game includes 6 gears, 9 shafts, and handle; made by Child Guidance Inc.</td>
</tr>
<tr>
<td>1</td>
<td>handle from above toy</td>
</tr>
<tr>
<td>2</td>
<td>shafts from above toy support board</td>
</tr>
<tr>
<td>1</td>
<td>1/8&quot; Plexiglas sheet</td>
</tr>
<tr>
<td>1</td>
<td>1/8&quot; Plexiglas sheet</td>
</tr>
<tr>
<td>1</td>
<td>1/8&quot; Plexiglas sheet</td>
</tr>
<tr>
<td>1</td>
<td>1/8&quot; Plexiglas sheet for base</td>
</tr>
<tr>
<td></td>
<td>plastic cement</td>
</tr>
</tbody>
</table>

The twin gear pump was also constructed as a closed pump (Figure 10) and used both as a demonstrator and as a source of fluid pressure. Air entrainment is the method used for monitoring fluid movement.
Plate 5. Twin gear pump
Figure 9. Twin gear pump,
open design

Figure 10. Twin gear pump,
closed design
Valves

Unit 6. Needle check valve

This is also called needle style simple relief valve.

Figure 11 shows the disassembled view.

Bill of materials

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1(\frac{1}{2})&quot; Plexiglas square rod</td>
<td>3(\frac{1}{2})&quot;</td>
</tr>
<tr>
<td>1</td>
<td>1(\frac{1}{2})&quot; Plexiglas square rod</td>
<td>1&quot;</td>
</tr>
<tr>
<td>1</td>
<td>3/4&quot; Plexiglas rod</td>
<td>2&quot;</td>
</tr>
<tr>
<td>2</td>
<td>1/4&quot; OD copper tubing</td>
<td>2&quot;</td>
</tr>
<tr>
<td>1</td>
<td>1/4&quot; brass spring</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>

plastic cement
Plate 6. Needle check valve
Figure 11. Needle check valve

This is a disassembled view of one of the simplest of all hydraulic valves. The cover for the device is not shown.
Unit 7. Ball check or ball type simple relief valve

This valve is shown in disassembled view in Figure 12.

Bill of materials

<table>
<thead>
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<th>Description</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>glass marble, approximate diameter</td>
<td>$\frac{1}{8}$&quot;</td>
</tr>
<tr>
<td>1</td>
<td>1$\frac{1}{2}$ Plexiglas square rod</td>
<td>3$\frac{1}{2}$&quot;</td>
</tr>
<tr>
<td>1</td>
<td>1$\frac{1}{2}$&quot; Plexiglas square rod</td>
<td>1&quot;</td>
</tr>
<tr>
<td>2</td>
<td>1&quot; OD copper tubing</td>
<td>2&quot;</td>
</tr>
<tr>
<td>1</td>
<td>$\frac{1}{4}$&quot; OD brass spring</td>
<td>to suit</td>
</tr>
<tr>
<td></td>
<td>plastic cement</td>
<td></td>
</tr>
</tbody>
</table>
Plate 7. Ball check or ball type simple relief valve
Figure 12. Ball check or ball type simple relief valve
Unit 8. Control or mixing valve

This is a rotary 3-way manually-operated directional control valve, or a 2-inlet single-outlet mixing valve for fluid composition control.

**Bill of materials**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1&quot; Plexiglas rod</td>
<td>1&quot;</td>
</tr>
<tr>
<td>1</td>
<td>( \frac{3}{8} )&quot; Plexiglas rod</td>
<td>2&quot;</td>
</tr>
<tr>
<td>1</td>
<td>3/4&quot; Plexiglas sheet</td>
<td>6&quot; x 7&quot;</td>
</tr>
<tr>
<td>1</td>
<td>3/4&quot; Plexiglas sheet</td>
<td>3&quot; x 3&quot;</td>
</tr>
<tr>
<td>2</td>
<td>1/8&quot; Plexiglas sheet for top and bottom covers</td>
<td>6&quot; x 7&quot;</td>
</tr>
<tr>
<td>3</td>
<td>( \frac{1}{2} )&quot; OD copper tubing</td>
<td>2&quot;</td>
</tr>
</tbody>
</table>

plastic cement
Plate 8. Control or mixing valve
Figure 13. 3-way rotary control valve
Unit 9. Closed center 3-position 4-way manually-operated spool valve

This valve was used to cycle a cylinder and to lock it into any intermediate position.

All discs, spacers, and boots are center drilled \( \frac{1}{4}'' \) to allow a \( \frac{1}{2}'' \) 20 brass rod to pass through all parts to assemble the unit. The \( 1\frac{1}{2}'' \) spacers give just enough room to allow water to flow around them.

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1( \frac{1}{2}'' ) ID Plexiglas tubing</td>
<td>6( \frac{1}{2}'' )</td>
</tr>
<tr>
<td>4</td>
<td>1( \frac{1}{2}'' ) wheel cylinder boots</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1( \frac{1}{2}'' ) Plexiglas discs</td>
<td>3/8''</td>
</tr>
<tr>
<td>2</td>
<td>1( \frac{1}{2}'' ) Plexiglas discs</td>
<td>( \frac{1}{2}'' )</td>
</tr>
<tr>
<td>3</td>
<td>1 3/4'' Plexiglas discs</td>
<td>( \frac{1}{2}'' )</td>
</tr>
<tr>
<td>2</td>
<td>1'' Plexiglas rod for spacers</td>
<td>7/8''</td>
</tr>
<tr>
<td>1</td>
<td>1'' Plexiglas rod for spacers</td>
<td>3/4''</td>
</tr>
<tr>
<td>1</td>
<td>1'' Plexiglas rod for spacers</td>
<td>9/16''</td>
</tr>
<tr>
<td>2</td>
<td>1'' Plexiglas rod for spacers</td>
<td>1( \frac{1}{2}'' )</td>
</tr>
<tr>
<td>5</td>
<td>( \frac{1}{4}'' ) OD copper tubing</td>
<td>2''</td>
</tr>
<tr>
<td>1</td>
<td>( \frac{1}{4}'' ) 20 brass rod, threaded</td>
<td>to fit</td>
</tr>
<tr>
<td>2</td>
<td>( \frac{1}{4}'' ) 20 brass nuts</td>
<td></td>
</tr>
</tbody>
</table>

plastic cement
Plate 9. Closed center 3-position 4-way manually-operated spool valve
Figure 14. Closed center 3-position 4-way manually-operated spool valve
Unit 10. Compound relief valve

This compound relief valve (Figure 15) can also be used as a sequence or counterbalance valve.

The upper spring-loaded valve sets the pop-off pressure; the lower valve is hydrostatically balanced and moves only after the upper valve opens. The lower outlet pipe is the controlled output.

Bill of materials

<table>
<thead>
<tr>
<th>No.</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1&quot; Plexiglas sheet</td>
</tr>
<tr>
<td>3</td>
<td>1/2&quot; Plexiglas rod</td>
</tr>
<tr>
<td>3</td>
<td>3/4&quot; Plexiglas rod for caps</td>
</tr>
<tr>
<td>2</td>
<td>10-32 brass screws</td>
</tr>
<tr>
<td>2</td>
<td>1/8&quot; brass springs</td>
</tr>
<tr>
<td>4</td>
<td>1/8&quot; OD copper tubing</td>
</tr>
</tbody>
</table>

The hydraulic gage (Figure 16) performs the double function of a pressure gage or a vacuum gage. This gage when connected to the compound relief valve, allows the student to see small changes in system pressure as an adjustment is made on the pop-off valve.

This is achieved by using two overhead projectors. The gage is placed on one and the valve on the other. Both projections can be put upon the same screen.
Plate 10. Compound relief valve
Figure 15. Compound relief valve
Figure 16. Hydraulic gage
Actuators

Unit 11. Single-ended double-acting hydraulic cylinder

Made of clear plastic, it is easy to see internal functions of the cylinder. However the round sides of the tube distort the light from the overhead projector. A new design is contemplated where the cross-sectional shape would be a flattened rectangle with rounded corners.

Bill of materials

<table>
<thead>
<tr>
<th>No.</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1½&quot; Plexiglas tubing 6½&quot;</td>
</tr>
<tr>
<td>2</td>
<td>1 3/4&quot; Plexiglas rod 7&quot;</td>
</tr>
<tr>
<td>1</td>
<td>1&quot; Plexiglas rod 1&quot;</td>
</tr>
<tr>
<td>2</td>
<td>1&quot; Plexiglas rod 1&quot;</td>
</tr>
<tr>
<td>1</td>
<td>1&quot; ID Plexiglas tubing 1&quot;</td>
</tr>
<tr>
<td>1</td>
<td>1½&quot; Plexiglas disc ¼&quot;</td>
</tr>
<tr>
<td>2</td>
<td>1½&quot; wheel cylinder boots 1&quot;</td>
</tr>
<tr>
<td>4</td>
<td>10-32 brass screws 1&quot;</td>
</tr>
<tr>
<td>2</td>
<td>¼&quot; OD copper tubing 2&quot;</td>
</tr>
<tr>
<td></td>
<td>jute packing for shaft</td>
</tr>
<tr>
<td></td>
<td>plastic cement</td>
</tr>
</tbody>
</table>
Plate 11. Single-ended double-acting hydraulic cylinder
Figure 17. Single-ended double-acting hydraulic cylinder
METHODS AND PROCEDURES

The experimental model used was a non-equivalent control group design. (3) It was quasi-experimental in nature for the classes which were available had to be used as they existed. No pre-matching within a class was possible.

This design is often expressed in the \( O_1 X O_2 \) format. \[ \begin{array}{c}
O_3 \\
0_4 
\end{array} \]

In this format the Os refer to test influence, and the X denotes an experimental treatment.

Selection of the Sample

Six classes of eighth grade industrial arts students at Merrill Junior High School, Des Moines, Iowa were used. They were divided into two groups of three classes each.

A randomized procedure for assignment of treatments to classes was developed. The numbers one to six were placed in a box. In a second box were placed three green rings and three red rings. One person drew a class number; then a second person drew a ring. If it was green, that class would be an experimental; if red, a control. The procedure was repeated until all six classes were assigned.

The class size ranged from 16 to 23 with an average size of 20. This gave a total sample of 120 boys, 57 experimental and 63 control. These numbers were reduced to 54 and 57
respectively by subsequent removal of any student from either
group who was absent three days or more.

Teaching Design

Both groups were given a two-part pretest.

The control group was taught each of the concepts using the standard plastic transparency method. The experimental group was given a quick introduction with the standard transparency; but then was shown each concept as it worked on an actually functioning teaching device.

In both groups every question asked by any student was answered completely and as concisely as could be accomplished with the medium being used in his specific group.

In the control classes the transparencies were presented in combinations or systems to mock up hydraulic circuits. In the experimental classes, the hydraulic parts were assembled into actual fluid-filled circuits. In these experimental circuits, the pumps were controlled by the valves which in turn controlled the actuators. During this time the fluid movement was illustrated by the projection of entrained air bubbles, fluid ripples, or an introduced medium such as black pepper. See Figure 1.

The hour before school each day was set aside for a review session where any student who missed one or two days was assigned to cover the lecture he had missed. This was again done
in segregated groups with the experimental and control sessions being assigned to alternate days.

The experiment lasted for ten consecutive school days. The material covered on these ten days is outlined in the teaching schedule. The tenth day was used to administer a posttest identical to the pretest.

Approximately three months after the completion of the experiment, the students were again assembled and given the same test as a retention test.

Preparation of Tests

The pretest was developed in the following manner. One hundred questions were taken from tests used by nationally recognized schools for summer institutes in hydraulics. These 100 questions were chosen because they covered the material which the functioning teaching devices were constructed to explain. The 100 questions were again reduced by removing any slight repetitions until 60 questions remained.

These 60 questions were subjected to an item analysis. For this, three groups of people were available. These were a group of 20 ninth graders of below average IQ and low socioeconomic background, a group of 20 randomly selected ninth grade students, and a group of 15 ISU graduate students.

This item analysis made it possible to remove any misleading or poorly-worded questions.
Upon completion of the item analysis too many questions remained, so the number was further reduced by removing any question which required mathematical solution or formula. This was done to remove any extraneous effects from a special background in mathematics (or lack thereof) for any particular student or group of students.

Trial Test Period

The next step was a trial period of testing the equipment and transparencies. This was accomplished by conducting a teaching trial at Irving Junior High School, Des Moines, Iowa.

During this trial the students' comments were used to improve the equipment and the teaching technique, and to add color or information which would clarify or enhance the total interest of all the presentations.

This trial period was also used for an item analysis to check for question validity on the second half of the pretest. It was difficult to conduct an item analysis for this part of the test. This was due to the highly technical nature of the questions and was further complicated by the shortage of technically trained people in hydraulics.

A teaching outline was prepared and a teaching schedule was set up so that each class in the experiment would cover the same material in a similar way and at the same speed.
Teaching Schedule

The actual teaching schedule for covering the hydraulics concepts was as follows:

First day

The first 30 minutes were used to administer the first half of the pretest—that part covering general hydraulics information, nomenclature, and related material.

The second half of the period (approximately 25 minutes) was devoted to a mechanical torque conversion lecture using four teaching devices. These devices contained gears that differed both in size and arrangement. See Figures 2 and 3. This lecture was given to both the control and the experimental groups to assure similar backgrounds in basic mechanical concepts.

Second day

The second half of the pretest was given, followed by an explanation and demonstration of two hydraulic pumps—twin gear and internal-external gear. (See lecture Appendix A.)

Third day

Ten minute review of the previous day's material, then lecture on the vane pump, G-rotor pump, and cup piston pump.

At this point careful consideration was given to the fact that within any pump at some given time there is a sealed volume which is increasing. This must be followed in some sequence by a sealed volume which is decreasing.
Fourth day

A ten minute review was followed by the concepts of constant delivery and fixed displacement and the pressure capability of different pump designs.

This was high-lighted by using the sixth pump—a small displacer piston unit capable of producing 300 PSI (or more) with a one hand push.

Fifth day

Ten minute review of previous material, and lecture on the simple relief valve and check valve.

These were combined because a spring-loaded valve can accomplish both functions.

The next device covered was the compound relief valve. In the experimental group, a hydrostatically balanced unit was connected to a rubber rotor, pressure-compensated motor-driven pump. The device is used on one overhead projector; a second overhead projector is used to monitor system pressure. This is accomplished by using a transparent hydraulic gage.

Sixth day

Material reviewed and lecture given on how the hydraulic gage functions.

Students were allowed to blow into the tube; a contest of five or six students was allowed or encouraged. In this contest each student was allowed to blow for his greatest pressure and to suck for his greatest vacuum.
The last half of the period was used to explain how the compound relief valve can be used as a sequence valve or as a counterbalance valve.

Seventh day

Counterbalancing and sequencing continued. A sequence circuit for a clamp and drill arrangement for a drill press was discussed and illustrated.

The second half of the period was used for accumulators. Four basic types were covered: weight-loaded, standpipe or gravity, spring-loaded or mechanical, and air-pressured or pneumatic. The need for accumulators was explained. This included both their capability to reduce pulsation, and the capability to supply extra fluid when the system requirements exceed pump delivery.

Eighth day

Review and control valves lecture was conducted.

Functioning teaching devices had been constructed which were used to illustrate these valves: the 3-way rotary control valve, the closed center 3-position 4-way manually-operated spool valve, and the open center valve of the spool type.

The second half of the period was used to cover the hydraulic cylinder. A single-ended double-acting device was used. A circuit using a hand piston pump, the closed center 4-way valve, and the hydraulic cylinder was assembled. Then the cylinder was cycled through all positions.
Ninth day

Review of cylinders and lecture on six specific types of motors were covered. These were twin gear, internal-external gear, vane, piston, and G-rotor motors.

The last half of the period was used for circuit construction review. Student's questions were used as the basis for constructing several circuits using the functioning teaching devices for the experimental group. In the control classes, the transparencies were presented in combinations to mock up the circuits. The function of each circuit was reviewed or covered.

Tenth day

The posttest, which was identical to the pretest in all respects including instructions and answer sheets, was given.

The students were allowed one full class period to take the test. Those who completed the test early were asked to answer three questions pertaining to class interest and motivation. (For a detailed description, see Appendix C.)

Retention test day

A class period nine and one half weeks later was used to again administer the test. This was done to obtain a retention score for both the experimental and control groups.

Group Controls

Measures or characteristics on which controls were
exercised during this experiment to insure similarity between the experimental and control groups can be summarized as follows.

**IQ**  This was removed by using both an IQ test and an IQ interaction test.

**Reading**  The analysis of covariance was controlled on the Iowa Test of Basic Skills composite score. Three sub-parts of this composite score were contributed by a reading test.

**Hydraulics technology or experience**  The analysis of covariance was controlled on the pretest scores.

**Mathematics**  This was controlled in two ways. Mathematics is a part of the Iowa Test of Basic Skills composite score mentioned above. Second, any question which required any direct mathematical knowledge was removed from the tests.

**Special knowledge of torque conversion or related mechanics**  This was removed by giving all classes an introductory lecture covering all of those concepts necessary to understand the hydraulics course as planned.

**Posttest-retention test interval**  All of the experimental equipment was taken out of the building so that no student could see the equipment during this time.
FINDINGS

Data analyzed at the end of this experiment were as follows: pretest score, posttest score, current composite score from Iowa Test of Basic Skills (hereafter referred to as Iowa Test), Otis IQ Test score (approximately 13 years old), posttest gain score determined by subtracting the pretest score from the posttest score, and retention gain score found by subtracting the score of the pretest from the retention test score.

The class means and group means for each item are given in Tables 1 to 6. The class standard deviations and group standard deviations for each item are given in Tables 1 to 6.

Table 1. Comparison of means and standard deviations of control group classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Pretest Score</th>
<th>Iowa Test Score</th>
<th>Otis IQ Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M  SD</td>
<td>M  SD</td>
<td>M  SD</td>
</tr>
<tr>
<td>YA</td>
<td>20.33 4.95</td>
<td>67.1 24.5</td>
<td>112.1 12.4</td>
</tr>
<tr>
<td>YB</td>
<td>18.1 5.6</td>
<td>69.0 18.9</td>
<td>107.1 8.6</td>
</tr>
<tr>
<td>YC</td>
<td>17.7 6.8</td>
<td>68.0 25.9</td>
<td>109.1 15.5</td>
</tr>
</tbody>
</table>

These data were treated with an analysis of covariance. In this analysis the data were checked for significant difference between the gain scores of the experimental group and the control group. The covarying on the pretest scores and the
composite scores of the Iowa Test was undertaken to control for pre-knowledge and reading skill as an added precaution to remove any pre-bias that was inherent in the groups as they were assigned.

Table 2. Comparison of means and standard deviations of control group classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Posttest Gain Score</th>
<th>Retention Gain Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>YA</td>
<td>8.5</td>
<td>8.3</td>
</tr>
<tr>
<td>YB</td>
<td>12.9</td>
<td>5.6</td>
</tr>
<tr>
<td>YC</td>
<td>13.5</td>
<td>10.2</td>
</tr>
</tbody>
</table>

Table 3. Comparison of means and standard deviations of experimental group classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Pretest Score</th>
<th>Iowa Test Score</th>
<th>Otis IQ Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>XA</td>
<td>18</td>
<td>2.8</td>
<td>73.4</td>
</tr>
<tr>
<td>XB</td>
<td>21</td>
<td>6.2</td>
<td>72.6</td>
</tr>
<tr>
<td>XC</td>
<td>16.3</td>
<td>7.6</td>
<td>67.8</td>
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</table>

Table 4. Comparison of means and standard deviations of experimental group classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Posttest Gain Score</th>
<th>Retention Gain Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>XA</td>
<td>13.8</td>
<td>9.7</td>
</tr>
<tr>
<td>XB</td>
<td>16.2</td>
<td>2.95</td>
</tr>
<tr>
<td>XC</td>
<td>23.1</td>
<td>6.0</td>
</tr>
</tbody>
</table>
Table 5. Comparison of group means and group standard deviations

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest Score</th>
<th>Iowa Test Score</th>
<th>Otis IQ Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Y (control)</td>
<td>18.7</td>
<td>5.9</td>
<td>67</td>
</tr>
<tr>
<td>X (exp.)</td>
<td>18.8</td>
<td>6.2</td>
<td>71.4</td>
</tr>
</tbody>
</table>

Table 6. Comparison of group means and group standard deviations

<table>
<thead>
<tr>
<th>Group</th>
<th>Posttest Gain Score</th>
<th>Retention Gain Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Y (control)</td>
<td>11.7</td>
<td>8.8</td>
</tr>
<tr>
<td>X (exp.)</td>
<td>17.5</td>
<td>9.6</td>
</tr>
</tbody>
</table>

The Otis IQ scores were used to check for any significant difference in advantage which might occur for upper IQ students as against lower IQ students. This advantage was checked not only between groups, but also within groups; for example, the upper half of the experimental group was compared with the lower half of the experimental group. The split was made at the Otis IQ score of 110. This score of 110 is usually referred to as high average; it has a second feature of being very near the mean for both groups.

This test was the only one where it was necessary to supply any missing data. In each case where a student's IQ score
was missing, the mean IQ score for his class was substituted.

These data were analyzed by a computer using a regression technique due to the unequal n.

The statistical formula for data insertion was as follows:

\[ Y_{IJKL} = B_0 + B_1 T_I + B_2 Q_J + B_3 T_Q IJ + B_4 A_K + B_5 G_L + E_{IJKL} \]

where \( Y \) = dependent variable, \( B_0 \) = intercept, \( T \) = between group gain score, \( Q \) = between group Otis IQ score, \( T_Q \) = interaction IQ score, \( A \) = pretest score, \( G \) = Iowa Test score, \( E \) = composite error score. The subscripts IJKL vary from 1 to 2 respectively. This variation was due to the fact that two groups (control and experimental) were used.

The \( B \) values resulting from the regression run were

\[ B_0 = 11.57, B_1 = 5.20, B_2 = .97, B_3 = .50, B_4 = .65, B_5 = .17. \]

In the above formula the values \( Y \) through \( E \) inclusive were those used by the computer program when calculating the data contained in Tables 7 and 8.

The source instructional method in Table 7 refers to the posttest gain scores.

The three sources Iowa Test, pretest, and Iowa Test and pretest interaction denote the three control factors which were employed to remove from the data any biased residuals sums of squares before any tests for significance on the gain scores were computed.

The sources IQ and IQ interaction denote the data which were calculated while checking for an IQ advantage either
Table 7. Analysis of covariance for instructional method and intelligence advantage

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Residuals Sums of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional method</td>
<td>1</td>
<td>453.09</td>
<td>453.09</td>
<td>7.5299</td>
</tr>
<tr>
<td>Iowa Test</td>
<td>1</td>
<td>1243.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>1</td>
<td>1528.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iowa Test &amp; pretest interaction</td>
<td>2</td>
<td>2279.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td>1</td>
<td>10.98</td>
<td>10.98</td>
<td>.1825</td>
</tr>
<tr>
<td>IQ interaction</td>
<td>1</td>
<td>1.66</td>
<td>1.66</td>
<td>.0277</td>
</tr>
<tr>
<td>Error</td>
<td>105</td>
<td>6318.11</td>
<td>60.17</td>
<td></td>
</tr>
</tbody>
</table>

\[
F (1, 105) = \frac{7.5299}{0.05 (3.94)} = \frac{6.90}{0.01 (6.90)}
\]

within or between groups.

This analysis of covariance was used to test the first null hypothesis: there is no significant difference between the achievement of a control group using standard transparencies and an experimental group using functioning teaching devices.

The data when analyzed with degrees of freedom of 1 and 105 respectively gave the F value of 7.5299**. This value exceeded the table value of 6.90 necessary to reject the null hypothesis at the .01 level.

It can therefore be concluded that the experimental group did achieve significantly more than the control group.

This analysis of covariance was also used as the basis to test the second null hypothesis: there is no significant
difference between the achievement of low IQ students and high IQ students within the experimental group using functioning teaching devices.

When the data were analyzed for the IQ interaction F value at 1 and 105 degrees of freedom, a computed F value of .027 was found. This value was considerably below the table value of 3.94 which was necessary for rejection at the .05 level.

On the basis of this F test, there was insufficient evidence to reject the null hypothesis. Therefore there was not a significant IQ interaction apparent during the experiment.

Retention Test

The retention test was given on Monday, May 26, 1970. The posttest had been administered on Friday, March 20, 1970.

During the interval between these tests, all of the experimental material had been removed from the building.

A retention gain score which was calculated by subtracting the pretest score from the retention test score was added to the data.

Sixty-six of the original 110 students were available for this test; 32 students were from the experimental group and 34 from the control group.

The statistical treatment chosen was again the analysis of covariance. The data were again controlled on the Iowa Test, the pretest score, and the Iowa Test and pretest interaction.

The results of the computer run are summarized in Table 8.
Table 8. Analysis of covariance for retention gain score and intelligence advantage

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Residuals</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sums of Squares</td>
<td>Mean Square</td>
</tr>
<tr>
<td>Instructional method</td>
<td>1</td>
<td>2533.31</td>
<td>2533.31</td>
</tr>
<tr>
<td>Iowa Test</td>
<td>1</td>
<td>118.94</td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>1</td>
<td>344.57</td>
<td></td>
</tr>
<tr>
<td>Iowa Test &amp; pretest interaction</td>
<td>2</td>
<td>419.71</td>
<td></td>
</tr>
<tr>
<td>IQ</td>
<td>1</td>
<td>46.68</td>
<td></td>
</tr>
<tr>
<td>IQ interaction</td>
<td>1</td>
<td>360.69</td>
<td>360.69</td>
</tr>
<tr>
<td>Error</td>
<td>60</td>
<td>9388.7</td>
<td>156.48</td>
</tr>
</tbody>
</table>

\[
F(1, 60) \leq 0.05 \text{ (4.00)}
\]

\[
F(1, 60) \geq 0.01 \text{ (7.08)}
\]

This analysis of covariance was used to test the third null hypothesis: there is no significant difference between the retention of a control group taught with standard transparencies and an experimental group taught with functioning teaching devices.

This null hypothesis must be rejected. The adjusted data gave a computed F value of 16.1896**. With degrees of freedom of 1 and 60 respectively, the table value at the .01 level was 7.08. The F value of 16.1896** was highly significant beyond the .01 level.

It can be stated that there was a significant advantage in retention for the experimental group.
These data were also used as the basis for testing the fourth null hypothesis: there is no significant difference between the retention of low IQ students and high IQ students within the experimental group using functioning teaching devices.

The data when analyzed with degrees of freedom of 1 and 60 respectively gave an F value of 2.305 for the IQ interaction. This F value did not begin to approach the table value of 4.00 necessary for rejection at the .05 level.

There was insufficient evidence to reject the null hypothesis. Therefore there was no significant difference in interaction of the IQ scores affecting the retention within the experimental group.
The material tested in this project offers several advantages to the instructor in Industrial Education or related fields of mechanical sciences.

These are greater achievement, greater retention, a leveling of the inherent advantage of high IQ, maintenance of high class interest, and larger amounts of detailed information can be presented in a comparatively short time.

While displaying the above advantages, using these functioning teaching devices on an overhead projector helps maintain classroom control. This is because large groups of students can see all of the presentation; in a normal manipulative demonstration only those students who are close to the actual scene of action can see. The overhead projector enlarges this scene of activity to all of the audience and exposes all members of that audience to the same view of the concept.

Three advantages which have been pointed out in the previous chapter were a large gain in student achievement, an even greater gain in student retention of that achievement, and that this material gives the teacher a method of instruction where he can teach students with a wide range of ability. He can achieve greater results with the lower ability students and not detract from the achievement of the upper ability students.

These advantages are gained from the capability of the
functioning teaching devices to completely illustrate not only a concept, but to give a slow-motion study of that concept while it is in operation. This capability of total visualization which is inherent in all of the experimental devices removes the advantage usually associated with the high IQ.

Teaching the Academically Handicapped

To check further on the status of IQ within the framework of this experiment, a class of eighth and ninth grade special education students at Merrill Junior High School, Des Moines, Iowa were used. These students had IQ test scores of 60 to 75. Eight students were available and were divided into two equal sub-groups.

Both sub-groups were read the second half of the pretest by the instructor.

After taking this pretest, the control sub-group was given a lecture on hydraulics using the standard transparencies on the overhead projector.

The experimental sub-group was given no lecture of any type. Instead they received the teaching devices or "toys" as they called them. Each device was given to them in a predetermined sequence. The only help given was to show the boys how to hook up the device, fill it with water, and then start it to operate. They were allowed to "play" (so to speak) with the device for as long as they desired. While they were engaged in
their "play", the investigator asked leading questions. When they were finished, one of the sub-group demonstrated and explained the device to the others.

The results of this experiment were uniquely interesting. The first finding was student interest. The control sub-group lost all motivation, clamored for more activity, and insisted that this was too much like the rest of their classes. They became so disinterested, in fact, that they refused to complete the experiment and would not repeat the pretest for a posttest score.

Conversely the experimental sub-group completed all the "toys" that were available and then asked for more. They also took both the pretest and posttest and yielded a gain score. The resulting achievement was high within the experimental sub-group. Their gain scores were 18, 16, 13, and 8 for an average of 13.7. This was quite comparable to the gain score of test group X (experimental); but it was further enhanced by the fact that these gains occurred on a total test possibility of 33 points, instead of the regular 66. If a multiple of two is introduced into this gain score, giving an equivalent gain of 27 points on a test possibility of 66, the comparison is quite good.

The author does not suggest this as a new or alternative method of teaching low IQ students (average of sample approximately 70 in this study). The sample size was very small and
a repeat sampling technique is warranted. But it is believed that with academically handicapped students, the functioning teaching devices definitely have merit and warrant further research or study.

Student Interest

Another advantage of using the functioning teaching devices was greater student interest. To gain a relative interest score between the experimental and control groups, an open response technique was employed.

Upon completion of the posttest, each student was asked to respond freely to three basic questions giving his reaction to the method of teaching. The questions were: Was it interesting or boring? Did you learn anything? Did you like it? In short, would you want to do something like it again?

The students were also advised not to sign their names and that the papers would be shuffled by a fellow student, so that there was no way the teacher would know what paper came from what student.

One hundred seven of the students did respond. These responses were typed using the students' English and spelling on ditto masters. These comments were duplicated and given to teachers in two junior high schools (Merrill and Irving) in Des Moines.

These teachers were asked to rate each comment on a one to
five scale (responses, scale, and other pertinent data are included in Appendix C). After this rating was completed, all scores for each class were added and averaged.

This average yielded a score of 2.58 for the control group, and a score of 3.87 for the experimental group. Considering that a score of five was ideal, it can be deducted (on the basis of the data) that the experimental group liked the instructional method better or were more interested than the control group. In fact, when these two scores were subtracted, the difference was 1.29. Consider that 1.29 was exactly one-half of 2.58; it can be seen that the experimental group was half again as interested as the control group.

It has been previously pointed out that the mean achievement gain of the experimental group was half again that of the control group. The correlation between interest and achievement would therefore be approximately one to one or very high.

Economy in Teaching

This study was also undertaken to see if Industrial Education concepts could be presented to students in a faster or more economical manner.

The concepts and course material were taken from a series of lectures used in a six weeks summer institute for hydraulics. The lecture time involved in that session was approximately 20 days with eight hours of class time per day. That,
of course, equaled a class time of 160 hours. For the purpose of this study the time was reduced by a multiple of \(1/16\) to a final lecture time of 10 hours.

The control classes were taught with transparencies very similar to those used by the institute. The course of study was also very similar, the great difference being the shorter time span used to cover the total information.

The experimental group was taught the same subject matter, but with a much more efficient and revealing method.

The results support the contention that the experimental method was much more efficient. It was impossible for the control students to grasp this quantity of information and have any significant retention at all.

Conversely, the speed-up in time did not hurt the experimental group. In fact, when the original test was used at the institute with college graduates as the students, the score percentages were no higher than they were with eighth grade industrial arts students.

Range of Application

While in the process of constructing the material necessary to facilitate this project, many plastic devices were built. The area of hydraulics was found to be only a very small segment of the total areas where these devices could be constructed and used to great advantage.
Another area for which teaching devices have been built was power mechanics. In this area the author has built and used a diesel injector jerk pump, a diesel injector valve, timing chain models for teaching three types of cam timing, and a device which shows how to set the distributor points and how to replace the points and condenser.

In the area of torque conversion or lever advantage, several gear systems, v-belt pulley systems, block and tackles, and three types of basic levers have been built. The windlass, the winch, and apparently all basic mechanical concepts can be illustrated with limited problems.

In the area of earth science, the author’s wife has used the pepper pump models to illustrate stream bed or fluid flow concepts. The open twin gear pump was filled with water and sprinkled with pepper which was allowed to settle; when operated the pump deposited the pepper in sand bars. These sand bars appear on the inside of the curve on the downstream side, and in the eddies or ripples as in actual rivers. This was quite easily seen when projected on a screen.

In the area of electricity, the inner operation of motor starters, solenoids, switches, relays, and fuses could be illustrated. Placing a functioning fuse model on the overhead projector and then overloading the fuse to the point of destruction of the fusible link would illustrate fuse action. This experiment could be further enhanced by placing the
transparent voltmeter across the fuse and watching the projected voltages which occur across the fuse during its life span.

In the field of meat cutting, it would be possible to build transparent models of meat, for example a T-bone steak. This model would have removable sections of fat and other parts which are basic to the meat cutter's profession.

At the grade school level, many examples are open to our inspection. Teaching devices in art where plastic mountains, trees, and other small outlines could be assembled into pictures to illustrate an idea or concept could be easily made.

In social studies or geography, maps with different colored parts—perhaps states or groups of states—could be assembled by the students while demonstrating to their fellow students.

Applications of the functioning teaching devices to education are limited only by the imagination, interest, and the depth of the background of the instructor.
SUMMARY

The objectives of this study were to design, build, and test a group of functioning teaching devices to investigate their capability to improve concept formation for industrial arts students.

Twenty-five basic concepts of hydraulics were chosen. Sixteen functioning teaching devices were designed and built which would completely illustrate the 25 basic concepts. These devices were designed in such a way that they would show part placement, part function, and also monitor fluid movement through the device or system of devices.

These functioning teaching devices were designed to be used on the overhead projector. Pepper was introduced into the fluid which filled the device. When this device was projected onto a screen, the pepper in the fluid permitted the fluid to be monitored easily.

After designing and developing the functioning teaching devices, they were tested for their mechanical and hydraulic realism. Then a teaching trial was conducted to test their capability for improving concept formation among eighth grade industrial arts students. To do this, a non-equivalent control group design was employed.

Six classes of eighth grade industrial arts students at Merrill Junior High School, Des Moines, Iowa were used in this
study. The total sample of 120 boys was assigned by classes to one of two groups, control or experimental. A randomized procedure for assignment of treatments to classes was developed.

The pretest was developed from questions used for a test at a hydraulics summer institute. The questions in the first part of the pretest were taken from the hydraulics test and subjected to an item analysis.

The total test and materials were refined in a pre-experiment trial on a representative group. A course of study was defined and then used in the actual ten days experiment. The test was administered three times, first as a pretest before the experiment began, at the end of the experiment as a post-test, and later as a retention test.

Upon completion of the two weeks testing period, a gain score comparison for significance was completed with the aid of a computer. The specific format used was an analysis of covariance. The data were controlled on the current Iowa Test of Basic Skills composite score and the pretest score. A second part of the data analysis was used to find if an IQ advantage was inherent between or within either group.

Four null hypotheses were used as a basis for the experiment.

**Null hypothesis 1**

There is no significant difference between the achievement of a control group using standard transparencies and an experimental group using functioning teaching devices.
The data, after treatment by covariance technique and adjustment, yielded an F value of 7.5299**. This F value was significant beyond the .01 level, and this null hypothesis must be rejected.

The experimental group did achieve significantly more than the control group.

Null hypothesis 2

There is no significant difference between the achievement of low IQ students and high IQ students within the experimental group using functioning teaching devices.

The computer run (after the same pre-bias adjustments) gave an IQ interaction F value of 0.0277, and an IQ between groups F value of 0.1825. Both of these ratios were well below significance at the .05 level. This test and this experiment conclude that there was no basis on which to reject this null hypothesis.

There was no significant IQ interaction, and the IQ advantage has been leveled out.

A further check on IQ and its relationship to the experimental equipment was made by using a class of academically handicapped students. The test IQ of this sub-group ranged from 60 to 75. These boys were divided into two equal sub-groups. This was a limited sample--total N = eight students.

The functioning teaching devices were given to the experimental sub-group in a pre-selected sequence. No lecture of any
kind was given to this sub-group. Instead they were encouraged to play with the devices. The pretest and posttest were read to these students and they were required only to mark an appropriate box.

The academically handicapped control sub-group was also read the pretest after which they started the series of lectures using the standard transparencies. This sub-group became bored, refused to finish the experiment, and did not yield a gain score.

Conversely, the experimental sub-group gained an average of 13.7 points, asked for more "toys", and in fact exhibited a keen interest.

Null hypothesis 3

There is no significant difference between the retention of a control group taught with standard transparencies and an experimental group taught with functioning teaching devices.

Sixty-six students were available for this test. Thirty-two were in the experimental group and 34 in the control.

An analysis of covariance controlling on the Iowa Test of Basic Skills and pretest scores was again used.

The F value for this test was computed at 16.1896**. This F value surpassed the table value of 7.08 expected at the .01 level. This experiment and this test conclude that the null hypothesis must be rejected.

The experimental group did retain significantly more than
null hypothesis 4

There is no significant difference between the retention of low IQ students and high IQ students within the experimental group using functioning teaching devices.

After pre-bias adjustments, the F value for this test was computed at 2.3. This F value is well below the table value of 4.00 necessary for rejection at the .05 level.

Therefore the conclusion must be that there was no significant IQ interaction; the upper IQ students did not have any significant advantage of retention over the lower IQ students.

To obtain a comparable interest rating for the two test groups, an open response technique was used. Each student responded to three interest questions. Responses from 107 students were rated by a group of junior high school instructors.

After the ratings were summed and averaged for each group, a score of 2.58 out of a possible score of 5 was obtained for the control group. An interest score of 3.87 out of 5 was obtained for the experimental group.

These two scores represented a ratio of 1.5 to 1 in favor of the experimental group. Therefore the experimental equipment generated a high interest among the students.

The results of this experiment point out some very specific and helpful information for anyone who is endeavoring to teach machine or hydraulic concepts to students.
Achievement  A student can achieve significantly more when taught using a functioning teaching device on the overhead projector as compared to being taught with standard transparencies.

IQ  Teaching with these devices levels out IQ advantages that are inherent in concept formation by a standard method of lecturing. The experimental method of lecturing also levels out IQ advantages that are inherent in retention of the concepts.

Retention  The students remember the concepts they have learned when taught with the functioning teaching devices for a longer period of time than do the students who are taught by a more conventional method.


APPENDIX A

Lecture for the Twin Gear Hydraulic Pump

The information for this lecture was broken down into three main parts: engineering specs, lecture method or instruction, and related material of general interest.

Engineering Specs for General Twin Gear Pumps

A. One gear is driven.
B. One gear idles.
C. Inexpensive; easy to produce; any type of gear will suffice.
D. Tolerances are not critical.
E. Will produce a flow of 5 to 50 gal. per minute, depending upon the thickness of the gears
F. Pressures up to 1200 PSI are acceptable for a one stage unit.
G. Pulse is minimal for a constant displacement unit; total fluid pulses per revolution is equal to two times the number of teeth on either gear.
H. Total volume of displacement per revolution is equal to two times the volume of all of the tooth projections of one gear.
I. Displacement per revolution is fixed; can be varied only by cavitating the pump input line.
J. Cavitation of this pump will result in tooth pitting
and rapid wear.

K. Unit must be used in conjunction with a pressure relief valve.

**Lecture Method**

Use the non-functioning transparency.

Place an arrow showing rotation of one of the gears.

Ask the students to give flow direction of the fluid flow through the pump.

**Example** If you mark the arrow to denote a rotation of the red gear in a clockwise direction, the fluid will come into the pump at A and go into the external channel at B.

Allow the students to divide and argue here at this point; about one-half of the class will have the fluid flowing between the gears and a resulting reversed flow from B to A. This is, of course, wrong; for the fluid is trapped between the gear teeth and carried around the outside of each gear between the gear and the confining pump wall.

After the students have completely chosen up sides and picked a direction of flow, place the functioning teaching device on the overhead projector. Fill the space immediately around the gears with water until it comes to about 1/8" from the top of each gear. (Do not cover the gears.) Next sprinkle a generous layer of pepper on the water at each of the open port positions (marked A and B on the transparency.)

Use the bent wire crank to turn the handle of the gear causing it to move in the direction corresponding to the
direction you have previously given the red gear. The wire
crank is used to keep your hands from obscuring the view of the
projected image.

The projector is focused correctly when the pepper specks
can be seen moving around the outside of the gear and being
pushed out by the teeth of the opposing gear.

When this demonstration is completed correctly, no student
will question how the pump functions.

Related Material

This information should also be covered in the lecture.

Any pump works by having a volume within itself which can
first be made to expand and fill with fluid. This volume must
be enclosed and moved to a position where we want it to be re­
duced in size; then the fluid will be expelled from the pump.

In the twin gear pump, this volume is provided by the cav­
ity between two gear teeth. When the teeth of the two gears
move out of mesh, the tooth which leaves a cavity in the other
gear makes that cavity grow larger. This cavity is formed by
the two adjacent teeth of the same gear and the confining walls
of the pump. The cavity or volume will be made smaller when
the tooth of the other gear is pushed back into it as the teeth
of two gears re-mesh during rotation.

This pump is widely used for fluid transport and for fluid
energizing. It is used as the oil pump on many of our U. S.
cars. This is true of nearly all or all of the G. M. line of
automobiles.
This test was administered as the pretest, the posttest, and the retention test. It contains three basic parts.

**Part 1** 33 questions pertaining to general hydraulics background material and closely-related concepts

**Part 2** 33 questions pertaining to the inner workings of the 11 basic hydraulic devices; to answer the questions in part 2 the student must refer to part 3

**Part 3** Reproductions of the transparencies used in teaching, and therefore basic cross-sectional views of the functioning teaching devices

The test was given to the student as three basic pamphlets and could be given as a two-part test if desired.

The answer sheet used was an IBM mark sense sheet. A sample was included in this appendix.
Hydraulics Test

Part 1
1. Hydraulics is the study of

a. fluids at rest
b. fluids in motion
c. fluids under pressure
d. all of these

2. In cases where the oil demand intermittently exceeds the pump output, the device used to overcome this is called

a. accumulator
b. a flow-control valve
c. check valve
d. regulator

3. An advantage of a rotary hydraulic motor over other types of rotary power is

a. storage of energy
b. variable speed with constant torque
c. very little heat build-up under heavy loads
d. high torque at low pressure

4. Cushioning a cylinder is

a. done by use of external springs
b. done by use of internal springs
c. a deceleration device
d. not commonly used

5. Turbulent flow is described as flow in which

a. movement of one layer of fluid on another with all particles moving parallel
b. fluid particles moving in random manner
c. there is very little flow
d. there is little pressure drop

6. Piston speed is determined by

a. the relief valve setting
b. delivery of the pump in GPM
c. work load imposed on it
d. center condition of directional valve
7. A positive displacement pump is a pump that delivers
   a. a specific amount of hydraulic fluid to the system for each revolution
   b. a specific velocity of flow to the system
   c. a specific pressure to the system
   d. a variable pressure to the system

8. A pump of unbalanced design is so named because
   a. its misproportioned weight will cause it to vibrate
   b. there is side load on the rotor and drive shaft
   c. the design is not balanced to the needs of the system
   d. the mounting is on one side only

9. A device used for converting mechanical energy into fluid energy is called a
   a. directional valve
   b. relief valve
   c. pump
   d. convertor

10. A pump in which the volume per cycle can be varied is called a
    a. gear pump
    b. fixed displacement pump
    c. variable displacement pump
    d. volume delivery pump

11. The maximum pressure that may be developed in a hydraulic system is controlled by the
    a. pump
    b. actuating cylinder
    c. directional control valve
    d. relief valve

12. The system pressure in a hydraulic circuit at all times is equal to
    a. relief valve pressure setting
    b. pressure caused by the greatest resistance to fluid flow
    c. pressure caused by the least resistance to fluid flow
    d. the pressure capacity of the pump
13. The simplest directional control valve is a
   a. 4-way valve  
   b. rotary pilot valve  
   c. follow valve  
   d. check valve

14. A three-way directional control valve
   a. has three ports for flow into or out of the valve  
   b. can be placed in three positions  
   c. has three different uses  
   d. has three mounting positions

15. Center conditions are found only in
   a. 2 position valves  
   b. 3 position valves  
   c. 4 way valves  
   d. 5 way valves

16. A relief valve is a valve with the primary function
   a. of increasing system pressure  
   b. of limiting system pressure  
   c. of stopping system pressure  
   d. to lower system pressure

17. Sequence valves must be
   a. internally drained  
   b. internally controlled  
   c. externally drained  
   d. externally controlled

18. A condition in fluid flow where fluid does not entirely fill the space is
   a. channel  
   b. cavitation  
   c. aeration  
   d. chamber

19. Rate of flow through an orifice will
   a. increase as the pressure drop increases  
   b. decrease as the pressure drop increases  
   c. remain constant at all times  
   d. vary at all times
20. The principal flow of oil in a hydraulic system will always be

- through the line offering the greatest resistance
- through the line offering the least resistance
- divided equally through unequal resistances
- to the load

21. The speed of a fluid motor is controlled by

- enlarging the drain line
- increasing the volume of oil to the fluid motor
- installing a larger relief valve
- installing a directional control valve

22. An excessive amount of air in hydraulic fluid is

- aeration
- cavitation
- cushion
- choke

23. A closed center 3-position 4-way directional control valve has the following characteristics in the center or neutral position

- cylinder ports are blocked and pressure is open to tank
- all ports are blocked
- pressure port is blocked and cylinder ports are open to tank
- all ports are open

24. Counterbalance valves are used to

- by-pass oil from a pump to the reservoir
- limit pressure in a secondary line
- provide a back pressure on a heavily loaded cylinder to prevent the cylinder from falling
- direct flow from a cylinder to the reservoir

25. The flow control valve is used to

- control the displacement rate of the pump
- limit the amount of oil flow through itself
- limit the minimum rate of oil flow through a valve
- control the oil level
26. **What is a sequence valve?**

- **a.** a valve with the primary function of eliminating flow
- **b.** a valve with the primary function of directing flow in a predetermined cycle
- **c.** a valve with the primary function of helping direct flow back to tank
- **d.** a valve with a design similar to that of a slip valve

27. **Volume pumped in a given time is**

- **a.** displacement
- **b.** delivery
- **c.** cushion
- **d.** cylinder

28. **Three actuating cylinders, having an area of 1, 3, 5 sq. in. respectively, are hooked to a common pressure inlet line and are loaded with the same weight.**

   The first cylinder to move its load will be the cylinder with the area of

- **a.** 5 sq. in.
- **b.** 3 sq. in.
- **c.** 1 sq. in.
- **d.** all will move at the same time

29. **The net effective area of the rod end of a cylinder is**

- **a.** cavity
- **b.** piston
- **c.** annulus
- **d.** volume

30. **Force equals**

- **a.** pressure divided by area
- **b.** distance times pressure
- **c.** distance divided by area
- **d.** area times pressure

31. **A cylinder has an area ratio of 2:1. The maximum force which can be exerted by the piston rod will be**

- **a.** greater when oil is directed to the rod end
- **b.** equal in both directions
- **c.** half as great when oil is directed to the rod end
- **d.** two times greater when oil is directed to the rod end
32. Pressure in a hydraulic system is produced by
0 a. the pump
0 b. the relief valve
0 c. resistance to fluid flow
0 d. size of system

33. The pressure that is available in an open tank to force oil into the pump is the
0 a. system pressure
0 b. suction pressure
0 c. zero pressure
0 d. atmosphere pressure
Hydraulics Test

Part 2

Use in conjunction with part 3.
Refer to page A diagram

34-A1. The name of this valve is

0 a. check valve
0 b. 3-way valve
0 c. 4-way valve
0 d. sequence valve

35-A2. Port 4 is

0 a. an inlet port
0 b. a drain
0 c. a vent
0 d. a control port

36-A3. When this valve is functioning correctly

0 a. valve 8 moves first
0 b. follower 9 moves first
0 c. valve 7 moves first
0 d. 7 & 8 move together

37-A4. Port 3 is

0 a. drain
0 b. vent
0 c. inlet port
0 d. control port

Refer to page B diagram

38-B1. This is a

0 a. 3 position 5-way valve
0 b. 2 position 5-way valve
0 c. 3 position 4-way valve
0 d. 3 position 3-way valve

39-B2. In its present position, fluid could pass from port

0 a. 3 to 5 and 2 to 1
0 b. 2 to 4 and 3 to 5
0 c. 3 to 5 and 3 to 1
0 d. 2 to 1 and 3 to 1
40- B3. This valve is often used to
   0  a. cycle a cylinder
   0  b. raise a 1-way cylinder
   0  c. dump 2 cylinders to tank
   0  d. shut off one line

Refer to page 30 diagram

41- C1. This valve is a
   0  a. 3-position 3-way control valve
   0  b. 3-way spool control valve
   0  c. 3 position 4-way control valve
   0  d. 3-way rotary control valve

42- C2. This valve can also be used as a
   0  a. speed control
   0  b. flow divider
   0  d. sequence valve
   0  e. relief valve

43- C3. With the valve in the position shown, when the fluid
   comes in port 1, the fluid will
   0  a. all go out 2
   0  b. all go out 3
   0  c. go out both 2 and 3
   0  d. be blocked

Refer to page D diagram

44- D1. This is a
   0  a. G-rotor pump
   0  b. vane pump
   0  c. internal-external gear pump
   0  d. twin gear pump

45- D2. With the gears turning in the direction of the arrows,
   the fluid will enter the pump at port
   0  a. A and go between the gears to port B
   0  b. B and go between the gears to port A
   0  c. A and go around the gears to port B
   0  d. B and go around the gears to port A
46- D3. This pump could also be used as a
0 a. sequence valve
0 b. 1-way valve
0 c. centrifugal pump
0 d. fluid motor

Refer to page E diagram

47- E1. If equal pressures are put into both A and B, the rod C will
0 a. move toward the word "top"
0 b. stand still
0 c. move away from the word "top"
0 d. oscillate back and forth

48- E2. This is because
0 a. equal pressures hold the rod still
0 b. equal pressures cause shock waves that let the piston vibrate
0 c. equal pressures are on unequal areas
0 d. none of these

49- E3. This is a picture of a
0 a. double ended single-acting cylinder
0 b. single ended double-acting cylinder
0 c. single ended single-acting cylinder
0 d. double ended double-acting cylinder

Refer to page F diagram

50- F1. This device is called
0 a. twin gear pump
0 b. star pump
0 c. fluid motor
0 d. G-rotor pump

51- F2. With part 1 turning with the arrow, the fluid will
0 a. go out port 4
0 b. go out port 5
0 c. go out both port 4 and 5
0 d. come in both port 4 and 5
Refer to page G diagram

52- G1. This device is called

0 a. ball and spring
0 b. reversing valve
0 c. spring valve
0 d. check valve

53- G2. If fluid enters port 2, it will

0 a. move the ball (3) off its seat and go out port 1
0 b. compress the spring (4) and leave the ball alone
0 c. cause the ball to bounce up and down on its seat
0 d. push the ball tighter to the seat closing port 1

54- G3. If fluid enters port 1, it will

0 a. lift the ball off its seat and go out port 2
0 b. hydrostatically lock the ball in place
0 c. compress the spring and leave the ball alone
0 d. cause the ball to bounce and then reseat tighter

Refer to page H diagram

55- H1. This device is called

0 a. G-rotor pump
0 b. vane pump
0 c. 4 piston pump
0 d. internal gear pump

56- H2. With part 1 rotating with the arrow, fluid will

0 a. enter port 3
0 b. enter port 4
0 c. be trapped under 2
0 d. none of these

57- H3. This device can also be used

0 a. as a control valve
0 b. as a cylinder
0 c. as a fluid motor
0 d. none of these
Refer to page I diagram

58- I1. This device is a

0 a. 2-way valve
0 b. check valve
0 c. pressure reducing valve
0 d. sequence valve

59- I2. If the fluid enters port 2, what will happen?

0 a. fluid will go out port 1
0 b. fluid will compress the spring
0 c. fluid will lift part 3 from port 1
0 d. fluid will not go out port 1

Refer to page J diagram

60- J1. This device is a

0 a. piston pump
0 b. pneumatic piston
0 c. sealed piston
0 d. displacer piston

61- J2. Port 4 on the device serves as a

0 a. bearing
0 b. guide
0 c. seal
0 d. collar

62- J3. This device can be used to produce at its best

0 a. very low pressures
0 b. high pressures
0 c. negative pressures
0 d. none of these

63- J4. With springs or a weight added to pull down part 1, we can make

0 a. an accumulator
0 b. a sequence device
0 c. a timing device
0 d. a counterbalance valve
Refer to page K diagram

64- K1. This device is a
0 a. displacer piston pump
0 b. cup and piston pump
0 c. pump
0 d. vane pump

65- K2. Port 3 is
0 a. an outlet valve
0 b. a pressure reducing valve
0 c. a sequence valve
0 d. none of these

66- K3. The fluid will
0 a. enter port 1 and go out through part 2
0 b. enter port 1
0 c. go out port 1 and come in through part 2
0 d. go out port 1
Hydraulics Test

Part 3
Use with part 2.
DIRECTIONS: Read each question and its numbered answers. When you have decided which answer is correct, blacken the corresponding space on this sheet with a No. 2 pencil. Make your mark as long as the pair of lines, and completely fill the area between the pair of lines. If you change your mind, erase your first mark COMPLETELY. Make no stray marks; they may count against you.

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APPENDIX C

Interest Survey

This is a group of responses from 107 of the 120 students who participated in the experiment.

These responses were re-typed onto ditto masters using exactly the same grammar, punctuation, and spelling as the students wrote them. This was to eliminate any bias that could result from editing by the typist.

The first page is a sheet of instructions which were given to each of a group of teachers who rated the questions' responses after the experiment was concluded. These teachers marked an IBM answer sheet with five spaces for each number.

The breakdown of responses by classes (not available to raters) is as follows: experimental classes - 1 to 13, 31 to 52, and 73 to 88; control classes - 14 to 30, 53 to 72, and 89 to 107.
INTEREST RATING

This is a group of 107 student reactions to two methods of teaching. The students were asked three questions. These were:

1. Was it interesting or boring?
2. Did you learn anything?
3. Did you like it? In short, would you want to do something like it again?

Will you please mark the answer sheet, using a 1 to 5 scale as follows:

1. did not like it at all                                Bad
2. disliked it some                                    Below Average
3. neutral; does not really care                        Fair
4. liked it ok; was interesting                         Good
5. liked it very much                                  Excellent

Rate the students' statements according to the scale above.
1. I felt this class was good the toys we used helped a lot I wouldn't have understood it if you just explained it. The transparencies helped a lot too. I think instead of putting one of those toys on the overhead projector you should have the class gather round and look at the toy. The class also should sit closer to the screen because sometimes I could not hear you speak.

2. I think this class was ok but I think it would be more interesting if you gave us all a diagram on paper of what you're talking about, every thing else was just fine.

3. I thought that this course was very helpful in the understanding of hydraulics. I'm glad that our group of students got to use the toys because it would have been a lot more boring without them. I don't think that I learned an awful lot from it, but I enjoyed it.

4. This course in Hidraulics has been very interesting. I think the "toys" made it easier to understand and it wasn't quite so boring. I wish the class would be longer, because I forgot some of the early things we learned. This is because so many things are squeezed into such a small time it is hard to remember everything.

5. I thought that hydroelectries are intresting. I also think that the plastic experiments helped. The only bad part was the test

6. I did like, the course & it didn't get to boring.

The toys did make it easier to understand
7. The toys did help but I was not interested in the coarse.
8. I think that the models did help in understanding Hydraulics. It especially helped with the 3-way rotary valve and the G-rotor. Using the black pepper in some with the water also helped. I was surprised, but when I asked my dad about some pumps, he was baffled.

I feel that these weeks of studying hydraulics was interesting. It certainly wasn't boring to me, even though some thought it was.

9. I thought it was very interesting. But kind of boring.

The toys were a great help. Signed confusions

10. I thought the course was very interesting and I learned a great amount of facts and the toys made it easier to understand.

11. I think hydraulics was very interesting, and I think it helped quite a bit with all of those pumps and devices you made for us to actually see how they worked. I don't think I would have known a thing if it hadn't been for those.

12. The course did not particularly interest me however I have no ideas on improving it at this time.

13. I didn't like the course to put it frankly. It wasn't because the teacher did a bad job. It was taught excellently. It just doesn't seem to be the field I care for. I prefer other subjects but even though I wasn't interested I'll have to admit I did benefit and I seem to have more interest for hydraulics now.
14. I must say that the lectures on the transparencies had something to be desired as far as how interesting it was. However I do believe that the material itself is good and much can be learned. I think this can be very stimulating if it was put in a more interesting manner.

15. I think this class was fun but I think the toys would have been more interesting, and the toys more helpful in the learning process. Of course this is up to you. I think, like you said, I learned more in 2 weeks than I learn in more classes in 2 months! I bet that makes you happy!

16. I thought the class was boring at times but sometimes it were was interesting. The End

17. I thought it was interesting in some parts and not in some, it would of be more interesting if we could of used the toys more.

18. this was a informative class I feel I did better on the second test than the first I thought the toys would have been better. It is better than Mechanical Drawing.

19. I think this was a fairly fun class but it was boring at times.

20. I thought it was fair but I wouldn't go through it again if I had the choice. I would have liked it better if I was in an experimental group.

21. This class has been about as interesting as baked Rutabaga a' la tarcat.

22. I liked this two weeks better than mechanical drawing but
two weeks for me was enough. You are an excellent teacher.
23. Certain parts of this class were ok, but the transparencies were bad. The toys that you showed us made it a little more interesting, but the pump you showed us was the most interesting thing.
24. I thought it was a good course but using the toys would have been better
25. I did learn something, I hope the test will show that, but the first day I thought it was great. Then all we did for the rest of the week and the next week was looking at those plastic things on the overhead. And that got boring. But otherwise it was good.
26. I learned very much in this class in just the short time we were in here. I wished it would of lasted longer so I could learn more.
   P. S. It WAS FUN.
27. Hydraulics was interesting at times but alot of the time it was boring. I think using the toys would have been more interesting. It was better than Mechanical drawing. Also zzzzz snore sleep, yaun
28. I think it would have been more fun if we were toys. But I liked this better than electricity.
29. I thought that I learned more this week than from any other subject in such a short time. The toys would have been better but this was fun. It is an interesting coarse of hydraulics. I learned more in this than in electronics.
30. this was interesting and boring. I think I learned something. Your friend anonymous

31. I think this course was very interesting. I like it alot better than electricity. The so called "toys" helped me alot in learning about the subject. It would be a good idea (I think) to continue this subject since it relates to electricity so much. I enjoyed this hydraulics course.

32. I enjoyed it a lot. I think it was better than alot of technical stuff. I wish we had longer to study because was fun.

33. It was all right, the toys were interesting and fun but when we got into drawing after drawing I began to lose interest and it became boring. Toys were good though

34. This course was rather dull and boring. I got a little out of the course but no a real lot that it will help me later on.

35. I thought it was interesting. The models you had helped me understand each pump or gear more. I really didn't know a thing about hydraulics, and now I know some basic facts.

36. I thought the class was very interesting and fun. It would have been better if the size of the class was smaller. As for the course, I think it should be a week longer. Without the toys I wouldn't have learned a thing.

37. I think this was a very good course. I never thought I could learn this much about something I didn't know anything about so fast. The "toys" you made helped an awful lot,
because you could see what was going on if you didn't understand it. I think a course like this one should be standard in shop class, just like electricity. Making the "toys" of plastic helped an awful lot since you could see all the parts working.

38. I thought this class was quite interesting. I learned quite a bit about hydraulics. When I started this course, I didn't have the faintest idea what hydraulic was. The "toys" we used helped considerably. I learned more by watching them work, than hearing you lecture us on it and show us pictures. The End.

39. I felt this course was interesting and will help me in further work with hydraulics.

40. This course has been very interesting to me. I've learned a lot and you have been a good teacher. Even though there are guys who goof off I still learned a lot. Since I was a small I've wanted to know more about this subject. It's been very interesting and educational. Now I will know how fork lifts and earth movers operate.

41. I think it was interesting, but I didn't understand a thing you said. You talking about a checkvalved, and if you were to asks me about the stuff you told us, I won't be able to tell you the answers.

But I think it was fun. (until a test came.)

42. I really liked this course in Hydraulics. It was
interesting the way you presented it to our class. I learned a lot I believe and I probably would never have given hydraulics a second thought if you hadn't introduced us to it. I liked the way you took you time to explain everything fully. You're a Good Guy.

43. I think the course was fun and I learned alot. I liked to work with the pumps and valves but I wasn't sure about the names of the valves and pump. I'm sure other boys would enjoy it. (The toys I mean)

44. I didn't enjoy this course because I wasn't here the first week and didn't understand it.

45. I liked it it wasn't boring seeing the toys work. it was interesting.

46. I think it was very interesting and it was very educational. It showed me a lot

47. I think it was very interesting and an experience. and I feel if you use the toys and the transparencys it is much easier to learn.

48. After taking this course I learned a lot about hydraulics and that it was easy, fun, & didn't take much at all to learn it. I had fun learning.

49. I think it was an interesting class. I learned alot. But it would be easier if you took more time explaining things. The toys really helped alot

50. I think that this experimental group working with toys
taught me a lot. I think it is a good idea.

51. Half fun Half Boring

52. I learned a lot I didn't know it was interesting, but got boring at times. I think the toys helped me to understand it better.

53. These two weeks have been great except when you told us about hydraulics. The stories were interesting but the things about hydraulics bored me. In fact shop period bores me. I can't think of a thing related to hydraulics that would effect me in the future. I have never had the urge to become a farmer. I could have slept through the lectures.

54. This class is okay. I want to learn but there are a few nuts who don't want a learn but I do not blame them. They do not have to goof around and disturb everyone else.

55. 1. I thought I behaved well. I did an average job. 2. I know more than when I started.

56. I feel that this class is not very courtious. I don't think it is just since Mr. Jolly has been here. I think it has been all year and I am very much in favor of straightening this class up.

I am very interested in hydraulics and would like to learn a lot more about it. I feel that Mr. Jolly is an excellent teacher and puts up with a lot more than is necessary. I feel that if I learn more and get more interested hydraulics may be a part of my life.
57. In the beginning of the year no one took this class seriously, everyone goofed off in the lab and in the other room. No one also thought that this course meant nothing. About the teaching of this class with transparencies, everyone except a few, has a very low attention span. Toys and live demonstrations may encourage their imagination and may make them courageous enough so they will what to learn. Lecturing on a subject has always proved to be a big bore to me. Also delay may be better if some of the people in our class who make most of the trouble were split up and put in different classes.

You have to make the student want to learn and not be forced to

58. 1. I do not feel that this class is ideal. I feel that we could have learned more if a few people in the class, who's name I will not mention, had not been in here. I also feel that this class on the whole is good but when a few people in this class start messing around I think that every body else thinks that they should be able to also. I know this class is not ideal, but if a few people I know were in here it would do better

2. I feel that I know how more things work know that I have studied hydraulics, but I must say that it did get boring at times and I feel it would be more fun and interesting if we could be like the experimental group and at least be able to see a few of the toys to gain our interest back again.
59. 1. This class is not ideal. It was hard to learn because of goof-offs and I probably wouldn't learn anything anyway because of the goof-offs disturbing my studying and getting into arguments. This class is interesting but it isn't taught right. We are told only do something and it's hard to do when you don't know anything about the course and how to do it. And don't know any terms. Presentation on how you use it today would help. Class is not so dull if it weren't so strict.

2. Hydraulics is interesting and I have learned a great deal except terms.

60. 1. I don't think it was are fault we didn't bring pens today because we didn't know we were having a test.

2. I think these two weeks were fun and interesting except when you gave us lectures because one or two kids horsed around.

61. The major problems of this class are exactly as you said, caused by a small group. These people could be just out of the class for one day and I'm sure you would notice an extreme change for the best. This class is a perfect example of a minority running a majority. Even as I write this a few people are talking. Give them an inch and they'll take a mile.

P.S. I thought it was interesting, when I could hear. You might try terrorist tactics for a day.

62. I. I think this class is all right, some times, but we goof off sometimes to
II. Hydraulics are all right, I like it but I think it is a jip because it is boring to look at a picture of some thing, I think it would be better to watch it work.

63. The reason is not the teacher or the people it's just a dum, boring, stinking, lousy, unsensibly class and subject. Because I am positive I'll never ever ever use hydrolics in my live like half the other unimportant subjects.

64. 1. I think our class aditude is the same of any other class I've been in

2. I think I could like the subject if it was taught differently.

65. I do not feel that this is not the ideal class because of the fact that so many people are goof offs. I don't think I myself goof off too much however I do occasionally.

From the one example of the toys that I have seen, I believe that you can get more out of it because it keeps your interest and it shows how it actually works, rather than just talking about it.

66. 1. The group is ideal because they're a bunch of great guys, they might goof off a lot but you don't know them like I know them!

2. The hydrolics were boring but they were interesting. I think I pay attention to Mr. Doufran

67. 1) Well we are a young group and if we were as old as you we would have been through everything.
Comments  It is good to learn hydrolicts and it is also good to have some fun. And if you make this class without fun it will be even more boring and people will not want to listen as well as if there was some fun in the classroom.

68. I think these two weeks were more enjoyable than when we were taught by Bartlett but I do not think being in the controlled helped us as much as it would have if we were in the exp. group. I did enjoy our lectures & stories.

69. 1. The reason this class is lousy is because of Alborton, Smith, Martinez, and Wienerstrum.

2. I think Hydrolistics would be alot more interesting if we used the toys. I think lectures are boring and I don't think I learned much from them.

70. Well our class aduted could be better in fact a lot better. I know I have been giving people trouble in this class and I am sorry, but I'm not the onye in this class you can't blame me for everything, like to always do.

    P.S. I don't like Hydraltics.

71. 1. Perfect.


72. The majority of the people in this class don't try to disrupt the class. But a few people start things going and thats why the class ends up getting disrupted.

    The Hydraulics corse was a little boring but I think that it would have been more interesting if our group could have
used the models

73. 1. I think our class attitude is very bad, because three or four people ruin it then the rest laugh. Everybody runs around and goofs off. But there are some who behave the way they are supposed to

2. I think that you taught hydraulics very well and I myself think I learned quite a lot. But there are some who were not interested and goofed off.

74. I felt the course was interesting. It was easy to understand, and the pumps made it fun.

The toys were a great aid, and showed us how the ideas worked, instead of just explaining it (as in electronics, which I didn't particularly enjoy, especially the reading.)

Hydraulics is a worthwhile subject, and if a person were going to go to a vocational school, it might expand his interests enough to take it, if it was offered.

75. I think it's interesting up to a certain point, then it gets boring. I like working with it.

The toys made it easier to understand. I think hydraulics is a good thing to study. I think it's very beneficial for everyone.

76. 1. I thought hydraulics was interesting. (better than mech. drawings will be).

2. With the toys it was easier to understand!

3. I thought that hydraulics was pretty good.
77. Yes, I thought it was very interesting. I liked it.
   2 The toys were very useful. They were better than reading a book for two weeks.
   3 Yes, I like hydraulics better than elec.

78. Hydraulics
    very interesting (for a 2 or 3 week period) but not longer for students at our level
    the toys were good but pretty expensive for school use.
    hydraulics - fun to study for a change

79. I think Hydraulics are interesting I think I like still like it better than drawing.
    I learn more from the toys than the diagrams. Hydraulics is a good study.

80. I thought hydraulics was very interesting.
    I like the plastic toys they were fun and helped better than the transperensies
    Hydraulics is fun I would like the do more of it.

81. I think learning about something I know nothing about can always be interesting. I don't think hydraulics should be taught on an 8th grade level under a system where shop is required, maybe it would be better in a 9th grade class.
    On the toys, I feel the transperencies were nessasary, but so were the clear plastic toys. I would never have understood the G-rotor if it weren't for the toys. YOU CAN'T DO WITHOUT THEM.
Hydraulics I didn't find much fun, and don't really enjoy shop as a whole. But I don't really feel I needed to learn hydraulics, so I didn't too well.

82. It was pretty interesting. It would of been better if we could of gone slower.

The toys helped me visualize the way they worked - esp. the G rotor

Hydraulics, no doubt, is an expanding field & I believe it should be taught in 8th shop for at least 4 weeks

83. interesting--it was pretty interesting

the toys were good, they were better than just have picture. with toys you could demonstrate things

All in all hydraulics wasn't bad

84. 1. It was fairly interesting but I rather work in wood shop.

2. The were very interesting

3. Hydraulics is quite interesting

85. 1. It was very interesting

2. I thought they were intresting.

3. Hydraulics are very fun.

86. 1. Very Interesting.

2. The toys helped me understand how motors (ect.) work.

3. Hydraulics is a fun subject and I learned alot.

87. Yes I think it was but I don't know why we did it.

I think you can learn a lot from the toys you can see how
they work and they are a lot better the the transparase.

I don't like the study of it but I like it a lot better than I did when I started.

88. Interesting - Yes it was interesting to me. I thought it was a lot of fun and I hope we continue to do it.

Toys - the toys were the best part of the whole thing. I think if we didn't have them I wouldn't understand hardly any of the pumps or anything.

Hydraulics - fun! I like it. I liked it better than electricity.

89. I think it's boring because it's sort all the same thing I think you should change the subject of and on. I liked it when you started talking about cars.

90. Like wow man!

91. I thought it was a fun class and it was very educational I learned a lot from it and it may come in handy some day. I liked it very much and thank you for teaching us. at times it was boring but the rest was interesting

92. I found the hydraulics course quite interesting. Although two weeks is a small amount of time to squeeze in a course, it was nonetheless interesting. I think more time should be spent in hydraulics and maybe in another interesting area you touched on - engines. The class was a good change from electricity to say the least et cetera...

93. I thought the course was fairly interesting because I had
never known what hydraulics was before and I liked it. But think it would have been more interesting if we would have used the toys.

94. Yes, because you learn what hydraulics do and what they are for.

95. I don't think the coarse was very interesting because I didn't understand all the moving parts of gears & stuff.

96. I think that this course was very interesting although I didn't act like I appreciated it I did. The control way was not as fun as the experimental. I also think that the class wasn't ideal either. All in all I really enjoyed this course, and I wish it could have been a longer course.

97. I thought this class could be very interesting if it went on for a longer time. At times it was very boring but on the whole it was very educational and fun. One of the things I liked best were the toy pumps that you demonstrated. The part I thought was boring were the pictures on the overhead but I learned alot I hope.

98. I think it is a worthwhile course, and you should know about Hydraulics - but I don't think it should be taught in 8th grade because I really don't think I got anything out of it. I listened and tried to learn but I can't - its just boring and I think it is a waste of time and it should be taught in highschool and not here at Merrill - maybe even in 9th grade it would be better. It is mostly hard to understand and
remember every little thing. If it were taught using the toys I think it would be more fun, interesting, and easier to understand so you can see how it actually works.

99. I thought the unit was very interesting and entertaining. But yet I would have learned more if we would have had the toys but still it was interesting and amusing. The reason why it was so interesting was because you explained it in a way that I liked & learned a little bit. I would like to look at the toys.

100. I thought it was boring. We went too fast & I didn't understand the operations.

101. I think this was a fun course. The way you taught it was good; you made it interesting. With any other teacher it would have been boring, and you have put a lot of work into those "toys." But I wish we could of had the toys.

102. I thought if we were taught a different method it would have been better. I learned nearly nothing in this class; and don't think I'll use what I did learn in the future.

103. I think it was very boring looking at a screen all day. Maybe if it was more interesting I would learn something.

P.S. It was interesting when we played with lie detector and the pumps and suck & blow machine.

104. I think this course was very interesting.

105. I think that it was a little boring but I think that I learned something from it.
106. I think it was fun but a little (not much) boring.

Me personally I think it would be more interesting if we played with the toys and learning at the same time.

It was really cool man.

I learned something.

107. I have not ever seen this type of teaching for a subject like this. I think it is a good way to teach the subject.
Comments of Academically Handicapped

1. I liked it very well because it was fun
toys like
interesting yes

2. WHY
Toys - like
interesting yes

3. I liked it very much because I learned things I didn't
know before.
I would like to do it again.

4. I liked it because it was interesting and fun and I want
to learned to learn to do it
APPENDIX D

Student Data Tables

These tables contain individual test scores for five tests.

The posttest gain score is found by subtracting the pretest score from the posttest score. The retention test gain score is found by subtracting the pretest score from the retention test score.

Table 9. Student data: control group Y section A

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