A STUDY OF INFORMATION ELEMENTS FOR INCLUSION IN AN INTRODUCTORY FLUID POWER COURSE FOR A DESIGN DRAFTING PROGRAM

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PREFACE

The reasoning behind this study was to determine the course content items for an introductory course in fluid power on the Associate Degree Design Drafting Technology level. Industrial representatives in Oklahoma are directly responsible for the results reported in this study. It is this cooperation from industry that keeps technician education up-to-date and pertinent to the ever changing world of technology.

I would like to express my appreciation to Dr. Donald S. Phillips whose guidance and advice has helped with my personal and professional development throughout my career.

The faculty of Cameron University was extremely helpful during the development of this study. I am indebted to Mr. Thomas Sutherlin whose occasional words of wisdom and encouragements throughout the study were deeply appreciated. I appreciated the concern he showed throughout the study.

Thanks are in order to Jim and Anne Conger whose friendship and help will always be cherished.

I am especially indebted to my wife, Lynda, whose love and sacrifices were an integral part in the completion of the study.

This study is dedicated to my Grandad, Mr. Jimmie Hysaw, who, as he puts it, is a small man from Tennessee, but who is the biggest man I know.

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CHAPTER I

THE PROBLEM

Introduction

Traditionally fluid power was thought of only in connection with water hydrology, the use of water to produce power by means of water wheels, or turbines. Similarly, air has been used for centuries to turn windmills or to propel ships. The use of water or air to produce power depended on the movement of vast quantities of fluid with nature supplying the needed pressure.

Today's engineer has developed a new field of technology called "Fluid Power Technology." This is the use of hydraulic pumps, controls and actuators which are self-contained in a unit on the machine or vehicle using fluid power. In a matter of some forty years, the applications of fluid power have become virtually limitless and include systems on machines, tools, automobiles, earth-moving machines, farm equipment, ships, locomotives, airplanes, and even in space vehicles. Because fluid power has advanced to such sophistication it has broadened into other fields. Automation has caused it to become joined with both mechanical and electrical systems. The technician is the key to this combination for he must convey his fluid power knowledge into industry in order to develop better and more effective fluid power systems. Therefore the technician must be educated in the most current fluid power techniques.

It is the job of the technical educator to see that this requirement is met. He must keep abreast of the changing industrial needs in order to insure an up-to-date technician to fill industry's job requirements.

Statement of the Problem

The problem with which this study is concerned is the lack of information necessary for developing a more effective fluid power course. The development of this course has been complicated by the following factors:

1. lack of current information concerning course content;
2. lack of information necessary to determine the types of hydraulic and pneumatic equipment used in industry today;
3. inability to keep abreast of changing developments in fluid power technology.

It is apparent that no course could meet the exact requirements for every fluid power design system. Identification of the principle information elements should be made.

Purpose of the Study

The purpose of this study was to identify specific information elements which are appropriate for inclusion in an introductory fluid power course for associate degree design drafting students. The study sought to determine what information elements are necessary as indicated by Oklahoma based industrial firms which use hydraulic and pneumatic systems.

Research Questions

The following research questions were considered:

1. What information elements should be included in an introductory fluid power course for associate degree design drafting students?
2. What fluid power facilities are necessary to adequately prepare the design drafting graduate for placement?

Need for the Study

During the industries' early beginnings, knowledge about fluid power was gained mostly from experience. Because fluid power technology has grown by leaps and bounds, because yesterday's "break-throughs" were today's "old hats", and because one had to run merely to stay even with new developments, there was little time to develop, either in universities or colleges, an educational program for the mushrooming technology.[1] Since this was the case in fluid power technology, many component manufacturers organized their own programs in fluid power training. These training programs became the backbone of fluid power education. But, as fluid power continues to grow and advance, the problem of education is becoming more accute. There is a need for formal education in fluid power at the community college and vocational education levels. It must also become part of the mechanical, agricultural and engineering curricula.[2] It is important that industry and education work together in developing course objectives so as not to burden down the schools economically by trying to change laboratory equipment on a continuous basis.[3] The need for more and better fluid power courses was summed up by Chuck Fletcher, the Director of Sales and Marketing of Pneumatics Company, when he said: "we feel that the junior colleges, the community colleges and even the universities are playing catch up ball. That's wrong. Many schools still do not teach fluid power."[4]

Delimitations

The study is restricted to identifying content appropriate for inclusion in an introductory fluid power course for associate degree design drafting students. The population of this study is limited to industrial representatives whose Oklahoma-based companies use fluid power systems. These industrial representatives work in the design division of their respective companies with fluid power components.

Assumptions

For the purpose of this study, the following assumptions were made:

1. The selected industrial representatives possess expertise in the fluid power field.
2. The selected industrial representatives will complete openly and accurately the Delphi Consensus.

Definition of Term

Fluid Power - the technology of the transmission, control, and storage of energy by means of a pressurized fluid in a closed system.

FOOTNOTES

[1]T. Goldoftas, "Fluid Power Education," Hydraulics and Pneumatics, December, 1977, p. 58.

[2]Bob Clippard, "Fluid Power Education," Hydraulics and Pneumatics, December, 1977, p. 59.

[3]Grant Venn, Man, Education and Work, The American Council of Education, Washington, 1968, pp. 18-28.

[4]Chuck Fletcher, "Fluid Power Education," Hydraulics and Pneumatics, December, 1977, p. 59.

CHAPTER II

REVIEW OF LITERATURE

By best estimates, shipments of fluid power components and systems in the United States should easily top $5 billion for 1977. This is about 10% over the estimated 1976 level of $4.6 billion, and nearly 20% over the down-cycle year of 1975, when shipments were estimated to be around $4.25 billion.[1]

If fluid power components were lumped into an identifiable standard industrial classification group like machine tools, lawn and garden machinery, or materials handling equipment, the value of fluid power components shipped would exceed any of these. In fact, it would be larger than the combined values of lawn and garden machinery and materials handling equipment.[2]

Figure 1 shows the estimated value of industry shipments since 1965. Though business cycle effects are apparent, the consistent pattern of strong growth is evident.[3]

The important fluid power component markets are mining and construction equipment, farm equipment, materials handling equipment (including industrial trucks), and metal working equipment. As shown in Figure 2, the long-term outlook for all of these markets is good with some being better than others.[4]

According to the U.S. Department of Commerce, shipments of mining and construction equipment are expected to nearly double by 1985. Farm

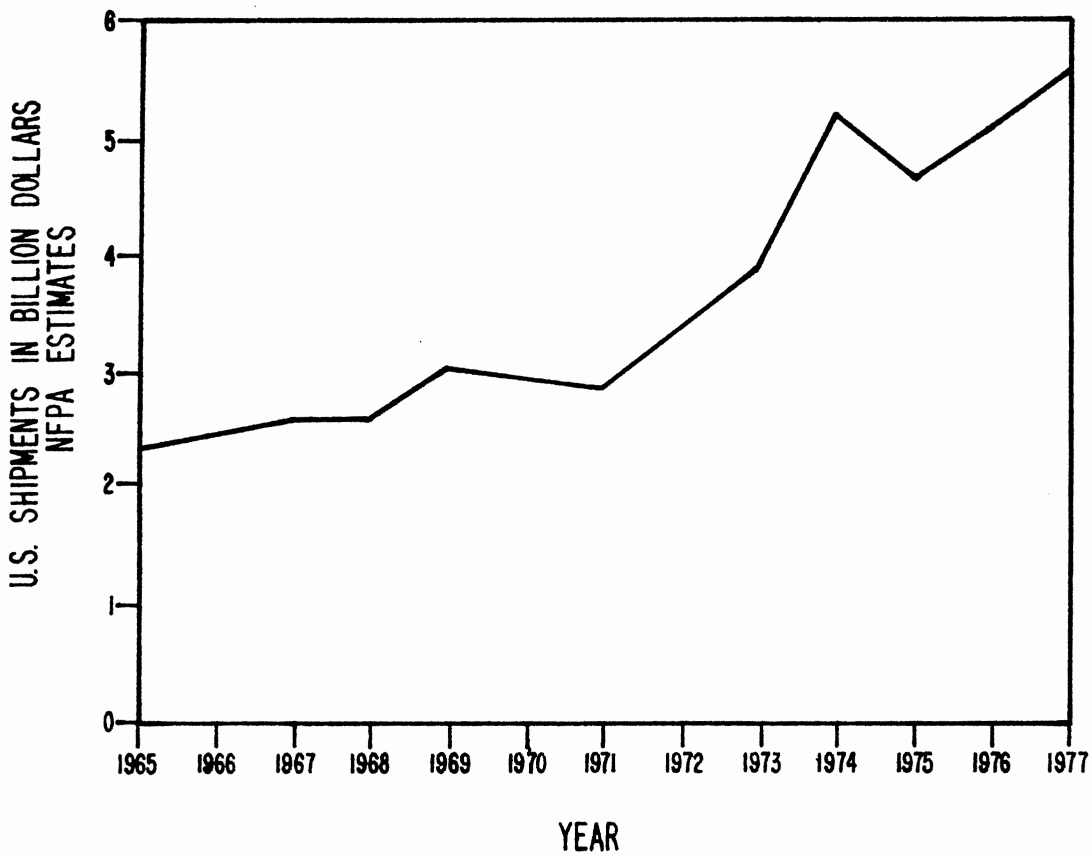

Figure 1. Estimated Values of Industry Shipments Since 1965

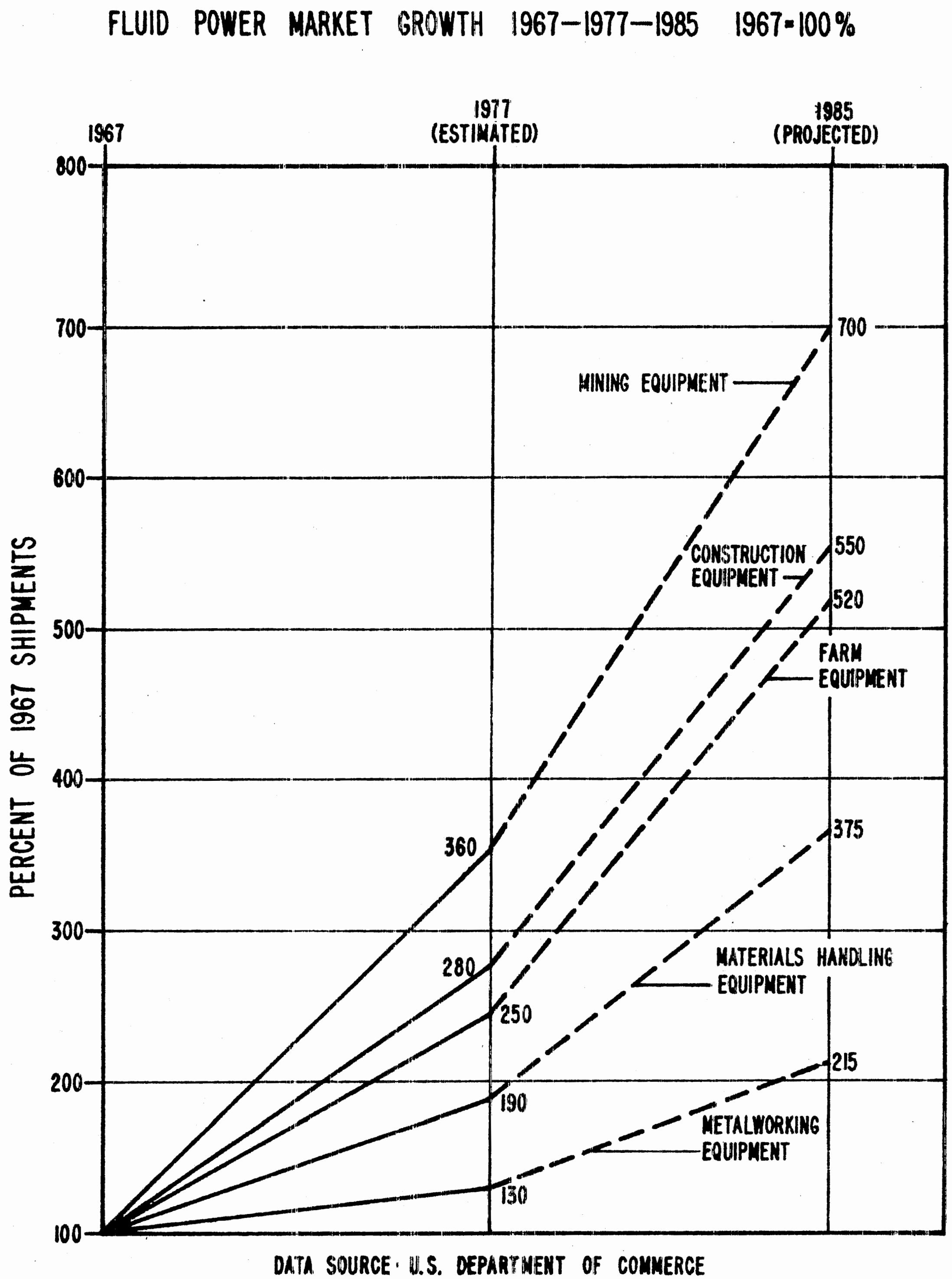

Figure 2. Long-Term Outlook for Five Markets that are Important to the Fluid Power Industry

equipment should do better than that. Materials handling equipment shipments should follow closely behind mining and construction equipment. Increases in metal working equipment production are expected to be roughly 65%.[5]

Mike Greenfield, Marketing Director of the National Fluid Power Association, says that: "The fluid power technologies that have been around for some time are coming into their own and the full impacts of these fluid power developments are yet to be appreciated. Fluid power technology will also be combined with developments in other areas."[6]

Professor S. C. Pritchett adds to this by saying: "Optimum automation would not be possible in many instances without the integrated advantages of fluid power, mechanical and electrical systems."[7]

Marianne Szabo, Managing Editor of Hydraulics and Pneumatics Magazine says: "Try to name a product that has not, some where along the line been handled, formed, stamped, treated, pushed, pulled or transported by fluid power."[8]

Theodore Pearce, the Executive Vice President of the National Fluid Power Association, sums it up by stating: "The applications of fluid power have become virtually limitless."[9]

Although the above statements are true, there is concern within industry today that colleges and universities are falling behind in fluid power education. Many schools still do not even teach fluid power.[10] The teaching of fluid power is left up to component manufacturers, distributors and industry. According to Mr. McDaniel, President of Hill Acme Corporation, this is not enough.

> Much of the fluid power skills and know-how were learned in the school of 'hard knocks'. I think that our biggest problem with hydraulic systems in the past has

> been our inability to get professional expert help. A sound education program which shows how to use hydraulics effectively would be a big help to the industry. Like any other technology, fluid power needs more effective training.[11]

Educationally speaking, fluid power, as applied to our economy, is a multidisciplined technology in contrast with the traditionally established engineering disciplines of electrical, mechanical, metallurgical, and chemical engineering. This involvement of the various engineering fields has been recognized by technical and vocational educators when considering the incorporation of fluid power into their curriculum. The need for texts and appropriate learning materials in fluid power is evident. Within this rapidly growing field and awaiting an opportunity to be educated are the craftsmen, technicians, technologists, engineers, salesmen, and customers. Combined with the shortage of texts and appropriate learning materials, the educational field of fluid power also lacks qualified teachers.[12]

According to W. C. Richards, the President of the Fluid Power Foundation,

> Teachers hesitate to venture into this multidisciplined form of technology because of the need to master such a widely diverse subject and also because of their inability to keep abreast of the accelerated advances in the state of the art.[13]

Harry Stewart and John Storer in their book Fluid Power go on to say that: "Because of this there is a need for an updating of the programs in fluid power education."[14]

Gary Smith, Rexnord Corporation's Chief Product Engineer further states this by saying: "Formal education is one of the major challenges the fluid power industry faces today: how to provide formal education as well as practical training in fluid power."[15]

Mr. A. C. Santorn, Manager, Education Services, Dupont, further assesses the need for fluid power education in his report to the National Conference on Power Transmission in Cleveland, in 1976. He reports that:

> There is a continuing and challenging need for industry to train and retrain its employees to meet the shortage of skilled workers, steadily rising costs, and increased technological complexity in operating plants within the fluid power industry. More efficient and effective training is required to increase productivity, reduce costs to yield increased profits, and improve overall performance.[16]

David Fromson and W. C. Richards sum it up in their cirriculum guide Fluid Power Technology by commenting that:

> In view of the increasing impact of technological developments in fluid power and its important and growing role in American industry, it is essential that personnel be trained in this field. There is a developing awareness of the value of highly skilled technicians who can work effectively with professional personnel and who can perform specialized tasks and services in fluid power.[17]

FOOTNOTES

[1]U.S. Industrial Outlook, 1977 U.S. Department of Commerce, Washington, D. C.

[2]M. Greenfield, "Fluid Power Industry Marketing Trends," Hydraulics and Pneumatics, January, 1978, p. 216.

[3]U.S. Industrial Outlook, 1977 U.S. Department of Commerce, Washington, D. C.

[4]Ibid.

[5]Ibid.

[6]M. Greenfield, "Fluid Power Industry Marketing Trends," Hydraulics and Pneumatics, January, 1978, p. 216.

[7]David Fromson and W. C. Richards, Fluid Power Technology, Garden City, New York, 1972, p. 1.

[8]Marianne Szabo, "Fluid Power - The Right Design Choice," Hydraulics and Pneumatics, January, 1977, p. 145.

[9]Charles S. Hedges, Industrial Fluid Power, Dallas, Texas, 1974, p. 8.

[10]T. Goldoftas, "Fluid Power Education," Hydraulics and Pneumatics, December, 1977, p. 59.

[11]Ibid., p. 60.

[12]Harry Stewart and John Storer, Fluid Power, Indianapolis, Indiana, 1968, pp. 1-3.

[13]David Fromson and W. C. Richards, Fluid Power Technology, Garden City, New York, 1972, p. 19.

[14]Harry Stewart and John Storer, Fluid Power, Indianapolis, Indiana, 1968, p. 2.

[15]T. Goldoftas, "Fluid Power Education," Hydraulics and Pneumatics, December, 1977, p. 59.

[16]A. C. Santora, "Need for Fluid Power Education" (unpublished speech presented to the 1976 Power Transmission National Conference, Cleveland, Ohio, 1976).

[17]David Fromson and W. C. Richards, Fluid Power Technology, Garden City, New York, 1972, p. 13.

CHAPTER III

METHODOLOGY

Introduction

The Delphi Technique is an intuitive methodology for organizing and sharing "expert" forecasts about the future. Delphi has been justified primarily on the grounds that it prevents professional status and high position from forcing judgments in certain directions.[1]

The Delphi method, as originally developed by the Ran Corporation, consisted of four steps. The fourth step was eliminated in this study because according to W. T. Weaver it is redundant in that nearly all of the results occur in Step 3.[2] He bases his opinion on research done by F. Cyphert and W. Grant.[3]

The three (3) steps used in the Delphi Technique of this study are as follows:

1. The participants were asked to write their opinions as to what subjects should be included in an introductory Fluid Power Course.

2. The participants were asked to evaluate all of their opinions in terms of a ranking order and list them.

3. The participants were asked to review the list and make any revisions that they deemed necessary. If no changes were made they were asked their reason for not doing so.

Participants

The experts who were employed in this study were chosen using the following criteria: (1) they were employed by industries operating in Oklahoma; (2) their employing organizations were currently using fluid power components in their design engineering applications; and (3) they have fluid power work experience.

Procedure

The first step in this study was to identify the users of fluid power components in Oklahoma. An index of the users of fluid power components was obtained in the Oklahoma Directory of Manufacturers and Products 1976. A letter was sent to the Presidents of each company to obtain the name of the individual who supervised the actual designing of fluid power equipment for that particular company. There were a total of 211 companies contacted with 75 companies responding.

A total of 25 companies (See Appendix A) was contacted for the first Delphi mailing. Included was a letter of transmittal and Correspondence Sheet Number One, instructing the participants in the use of the coded form (See Appendix B). Each participant was asked to furnish five subject items that they considered important for inclusion in an introductory fluid power course. The form was coded to insure that a follow-up could be completed. A self-addressed stamped envelope was provided to enhance the possibility of return of the Delphi form. To improve responses, a memorandum (See Appendix C) was sent along with another copy of Correspondence Sheet Number One.

To review the replies of the first Delphi mailing, a committee consisting of two Design Engineers from Burtek Incorporated was established. The responses were combined and listed according to their similarity. The list was condensed to eliminate redundancy and ambiguity and then placed randomly on Correspondence Sheet Number Two. A six-point continuous scale was provided to rate each item on the form with zero being least important and five being most important. Correspondence Sheet Number 2, a transmittal letter (See Appendix D) and a self-addressed stamped envelope were returned to the Delphi participants.

When the questionnaire was returned, the consensus index was computed for each item. The consensus index was determined by calculating the arithmetic mean for each subject content item listed.

The Delphi form was rewritten with the items receiving the highest consensus index being listed first and those receiving the lowest listed last. Items with the same index value were listed with the same rank number but different alphabetic characters were added to show individual items within the same rank order.

Correspondence Sheet Number Three, a letter of transmittal (Appendix E), and a self-addressed stamped envelope were returned to the participants. They were asked to re-evaluate their responses taking into consideration the consensus priorities. The participants were asked to revise their opinions in line with the group or indicate why they would not revise it.

Upon return of Correspondence Sheet Number Three, the responses were reviewed, grouped, and listed and a summary of the Delphi results was sent to the participants.

FOOTNOTES

[1]O. Helmer, Social Technology, New York, Basic Books, 1977.

[2]W. T. Weaver, "The Delphi Forecasting Method," Phi Delta Kappa, January, 1971, p. 268.

[3]F. R. Cyphert and W. L. Grant, "The Delphi Technique: A Tool for Collecting Opinions in Teacher Education," a paper presented at the AERA Symposium on Exploring the Potential of the Delphi Technique by Analyzing Its Application, Minneapolis, Minnesota, March 4, 1970.

CHAPTER IV

RESULTS AND ANALYSIS

The purpose of this study was to identify appropriate course content items for an introductory fluid power course. The study was accomplished by use of a modified Delphi Technique.

This technique allowed industrial fluid power "experts" to be contacted so that their opinions could be recorded. The number of responses appears in Table I.

TABLE I

SUMMARY OF DELPHI MAILING RESPONSES

	Delphi Correspondence Sheet		
	I	II	III
Number of questionnaires mailed	25	13	10
Number of responses to questionnaires	13	10	9
Percentages of responses to questionnaires mailed	52.00	76.92	90.00

Twenty-five questionnaires were originally mailed with 13 responding. Of the 13 responses to the first Delphi mailing, one of the participants indicated that his company would like to interview students for employment in this area. Midwestern Manufacturing Company of Tulsa, Oklahoma, said that "We would like to hear from gifted students available for employment in this area." Another of the correspondents from Kimray Incorporated of Oklahoma City indicated that "The student must also be able to communicate well, i.e. written, comprehension, verbal."

A follow-up memorandum was sent two weeks after the first mailing to the 12 who did not return the first questionnaire and only two responded. Of the 13 participants, nine were from Tulsa, three were from Oklahoma City, and one was from Bartlesville. It should be noted that this study dealt with industrial correspondents in Oklahoma only.

Delphi Correspondence Sheet Number One was used by the participants to identify five course content items (See Appendix B). Two Design Engineers from Burtek Incorporated reduced these items from 65 to 35 by combining and removing redundancies.

Ten participants ranked all of the items on the questionnaire with one of the participants adding two other items. These two items: quantity and pressure drops through orifices and orifice coefficients and different types were submitted to the group on the third questionnaire.

TABLE II

INTRODUCTORY FLUID POWER COURSE
CONTENT ITEMS IN RANK ORDER

Rank Order		Course Content Item
1.		Application, design of a complete hydraulic system
2.		Basic hydraulic components and their function
3.	A.	Sizing of piping lines and components
	B.	Hydraulics
4.		Basic principles of pressure and volume controls
5.		Valves - check valves, flow control valves, directional control valves, relief valves, reducing valves, counter-balance valves, one-two-three and four-way valves
6.		Fluid power symbols and standards
7.		Basic pneumatics
8.		Good design practices - filtering, heat build-up and removal, vibration control, design for maintainability
9.	A.	Study the properties of various fluids - compressibility, Boyles law, etc.
	B.	Study of fluid flow-orifices, pipes, etc.
10.		Principles of various types of pumps
11.		Principles of actuators
12.		Heat generation in hydraulic systems
13.		Materials - strength, workability, heat treating, elastomers, plastics
14.	A.	Electrical interface for hydraulic system controls
	B.	Preparation of plumbing layouts - selection of fittings line routing, mounting
	C.	Introduction to ANSI piping codes
15.	A.	Fluid logic circuit
	B.	Speed controls
	C.	Physics
16.		Introduction to ASME pressure vessel codes

TABLE II (Continued)

Rank Number		Course Content Item
17.		English
18.		Special purpose circuits - regeneration etc.
19.		Industrial shop processes
20.	A.	Study of fluid statics
	B.	Single line isometric drafting
	C.	Pipe and fitting drafting
21.		Kinematics
22.		Welding symbols and AWS standards

The items that had the same consensus index were given the same rank order but with different alphabetic characters. Appendix G lists the consensus index so that a comparison as to how close the rank order numbers actually are can be made.

The third questionnaire was made using the rank order in Table II and was mailed within a two-week time period. Upon receiving the third correspondence the participants were asked to review the items listed, indicate if any items should have a different priority, and tell why they should have a different priority. Table III lists the individual opinions of the participants who changed any item's rank order.

TABLE III

INDIVIDUAL OPINIONS OF PARTICIPANTS IN THIRD DELPHI MAILING

Item Rank Number on Third Correspondence	New Rank Number	Reason for the Change
6	Lower	Not used by many manufacturers of hydraulic equipment, aircraft yes.
6	14 D	Many companies have their own standards and symbols. Making the student conversant with some and adaptable to change should be all that is required.
12	8 B	Heat generation usually is not so severe a problem to require special emphasis.
17	Omit	Obviously knowledge of English is important to all professional people, however the subject does not appear to be germane to a technology course.
20 B and 20 C	14 B	Suggest these items be included with rank item 14 B.

The two items added to the third questionnaire, Quantity and Pressure Drops through Orifices and Orifice Coefficients and Different Types were only answered by seven of the nine participants. Using six as the denominator, both received consensus indexes of 3.123. This would give them a rank order between 9 and 10. Both of these items seem closely related to item 9B and this appears to be a reasonable location for them on the list. Three of the six participants who rated the added items also gave them a rank number. They all stated that "These items are important but do not need to be given separate subject matter status." The rank numbers given were one, inclusion into 3A, and two, inclusion into 4. This appears to contradict the consensus index of 3.123 that was given. Forty-three percent of those that ranked the two added items seem to feel that they should be of higher importance on the list.

Three weeks elapsed between the third Delphi mailing and the final cut-off date. Nine participants had responded to the final mailing. A breakdown on the participating industries and their location is given in Table IV.

TABLE IV

IDENTIFICATION OF DELPHI PARTICIPANTS

Number of Participants	Type of Company	
2	Manufacturers	Oklahoma City
3	Fluid Power Equipment Sales	Tulsa
1	Aircraft Simulators	Tulsa
1	Fluid Power Equipment Sales	Oklahoma City
1	Manufacturer	Tulsa
1	Research Design	Tulsa

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This study was brought about by the continuing need to update technician education. The field of fluid power is an ever changing technology. It is the job of the technical educator to see that the technician education student keeps abreast of the most current fluid power techniques. In view of this, the study sought to define certain information elements which should be included in an introductory fluid power course to help in the developing of a more effective course.

Summary

The purpose of the study was to identify specific information elements which are relevent for inclusion in an introductory fluid power course for associate degree design drafting students.

Fluid power experts throughout Oklahoma were contacted by use of a modified Delphi Correspondence technique. By use of this technique this study sought to answer the following research questions:

1. What course content items should be included in an introductory fluid power course for associate degree design drafting students?

2. What fluid power aids are necessary to prepare the design drafting graduate for employment?

Table II is a listing of course content items that industry chose. The items are listed in order of priority with the highest priority items being highest on the list.

Conclusions

The first research question was; what course content items should be included in an introductory fluid power course. The course content items are listed in order of priority and would be included in a fluid power course based on facilities. From the items which were ranked highest it can be concluded that there is an emphasis for "hands on" experience in fluid power. The items which were ranked lower indicate prerequisities for the technician such as kinematics, English, physics, isometric, pipe and fitting drafting and should not be included in a fluid power course.

The first six items on the list were given a ranking of 74% or greater. It can be concluded that these items are concerned with the basic principles of hydraulics such as application, components and valves, and symbols and standards. These items should be given top priority when developing an introductory fluid power course.

Items 7 through 15 were rated between 50% and 72%. These items deal with pneumatics, design practices, properties of fluids, pumps, and electrical interface for hydraulic system controls. They are not ranked as high as the top six items but should be included if possible in the course content to give the student a more rounded experience with fluid power. The first six items deal with the design of basic hydraulic applications, whereas the items 7 through 15 deal with the different systems that the technician might encounter when working with fluid power.

The final ranked elements 15C through 22 were given a rating of 50% or less. These items include English, physics, drafting, and kinematics, and should be taught as separate courses. They should not be included in an introductory fluid power course but are very essential in the total associate degree design drafting curriculum.

The second research question was; what fluid power aids are necessary to prepare the design drafting graduate for employment. All of the items in Table II could be taught without access to a hydraulic test bench with exception of item 14. Item 14 would require access to a hydraulic testing bench capable of simulating both hydraulic and pneumatic systems as well as solenoid control valves to show electrical interface with hydraulics. Even though the first items could be taught without a sophisticated hydraulic testing bench, industry usually expresses a desire for graduates to have "hands on" experience. This experience could be accomplished with a hydraulic testing bench. The industrial representatives indicated concern that the students have a thorough understanding of how all of the fluid power components operate and how each one is used. The hydraulic testing bench would allow the students to obtain a working knowledge of components and their different functions. The bench should be used in conjunction with the class lecture to give the student not only a book knowledge but also an essential working knowledge of fluid power. If used in conjunction with class lecture, the hydraulic testing bench would help the student to better understand the application of fluid power by allowing him to build and test actual fluid power systems.

Recommendations

With the emphasis being placed upon application and design of a complete hydraulic system, it is recommended that these systems be used to prepare design drafting graduates for placement. Hydraulic design applications should be an integral part of other design courses so as to allow the students to see many different types of design solutions.

The addition of a fluid power course into a design drafting program with these particular course content items should be based upon the strength of the existing program, availability of funds, and industrial needs. The fluid power course content items listed in Table II reflect the opinions of the Delphi participants in Oklahoma only and do not necessarily represent all industrial applications. These items are suggested course content items. It is up to the educator to decide how appropriate and in what order these course content items should be in an introductory fluid power course.

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Wolansky, W. D., John Nagohosian and Russell W. Henke. Fundamentals of Fluid Power. Boston, Massachusetts: Houghton Mifflin Company, 1977.

APPENDIX A

COMPANIES WHO RESPONDED AND WHO DESIGN WITH FLUID POWER

(DELPHI PARTICIPANTS)

*** Burtek, Inc.
Lynn Whisman
P. O. Box 1677
Tulsa, OK 74101

Central Supply
Jim Stuples
1300 Cache Road
Lawton, OK 73501

*** Chandler Engineering Co.
A. R. Kahmann
7707 East 38 Street
Tulsa, OK 74145

Dotts Industries
Syed Azeez
P. O. Box 156
Yale, OK 74085

*** Dresser Industries, Inc.
K. Michael Clark
P. O. Box 45470
Tulsa, OK 74145

*** Dresser Industries, Inc.
Toby S. Pugh
P. O. Box 45470
Tulsa, OK 74145

* D. W. Hearn Machine Works
D. W. Hearn
3201 East Reno
Oklahoma City, OK 73117

* D. W. Hearn Machine Works
Gary Worley
3201 East Reno
Oklahoma City, OK 73117

Ewbank Mfg. Div. Inc.
David Blundell
513 North Main
Fairview, OK 73737

Ewbank Mfg. Div. Inc.
Leon Goodwin
513 North Main
Fairview, OK 73737

*** Fluid Components, Inc.
Dave Tanner
P. O. Box 45526
Tulsa, OK 74145

* Kimray, Inc.
Garman O. Kimmell
52 NW 42
Oklahoma City, OK 73118

Machine Engineering
John W. Carter
1319 North Mingo Road
Tulsa, OK 74116

* Metal Goods Manufacturing Co.
Mrs. T. V. Pendleton
309 West Hensley Blvd.
Bartlesville, OK 74003

*** Midwestern Manufacturing Company
Cliff Lindsey
P. O. Box 3445
Tulsa, OK 74101

*** Nix Supply Company
Hank Taylor
P. O. Box 94936
Oklahoma City, OK 73147

Nowata Machine Works, Inc.
Darrel Fry
Box 678
Nowata, OK 74048

Parkhurst Corp.
Steve Parkhurst
15051 East Admiral Place
Tulsa, OK 74116

Piping Engineering Co., Inc.
Horace Ivy
Box 190
Sand Springs, OK 74063

Sawyer Manufacturing Company
Tom Sawyer
1031 North Columbia Place
Tulsa, OK 74110

Southern Burner Co.
Walter Snedeker
Box 885
Chickasha, OK 73018

*** Southwestern Controls
Rusty Church
6580 East 40 Street
Tulsa, OK 74145

* UEC Equipment Company
Steve Carson
P. O. Box 18879
Oklahoma City, OK 73154

** UEC Equipment Company
Dale Moss
P. O. Box 18879
Oklahoma City, OK 73154

*** Woods Sales Company
John B. Woods
P. O. Box 27035
Tulsa, OK 74127

* Responded to Delphi Correspondence Sheet No. 1.

** Responded to Delphi Correspondence Sheets No. 1 and No. 2.

*** Responded to Delphi Correspondence Sheets No. 1, No. 2, and No. 3.

APPENDIX B

TRANSMITTAL LETTER AND DELPHI QUESTIONNAIRE

SHEET NUMBER ONE

CAMERON UNIVERSITY LAWTON OKLAHOMA

Lawton, Oklahoma

The Design Drafting Division of Cameron University's Technical Department is evaluating courses and equipment to keep our program abreast of industrial needs. We feel that it is essential to maintain good communications with industry. With this in mind, I am conducting a survey to update our present course in Fluid Power.

The results of the study will be used to determine the course content of a fluid power course for Cameron University's Design Drafting Associate Degree Program. (A brochure on the existing Design Drafting program is enclosed.)

The Delphi Technique has been chosen as the method to be used in obtaining your opinion of the subject items to be included in the fluid power course. This technique, which is built on informed, sound judgement, is intended to obtain opinions from persons without bringing the individuals into any kind of face-to-face confrontation. Successive questionnaires and feedback are necessary with each round designed to produce more carefully considered group opinions. Four separate mailings will be used and spaced approximately two weeks apart.

Correspondence No. 1 — List five subject areas which should be included in a fluid power course for Associate Degree Design Drafting students.

Correspondence No. 2 — A list of course subject areas will be compiled from participants' responses and mailed back to you. Using this list, each person will evaluate and rank the subject items by importance.

Correspondence
No. 3

The average rankings of each subject item will be compiled from Correspondence Number 2 responses. Each participant will be asked to either revise his opinions in line with the priority list developed in Step 2 or specify his reasons for remaining outside the consensus.

Correspondence
No. 4

The average rankings of each subject item will be calculated from Correspondence Number 3 responses. Each participant will be asked to evaluate for the final time his responses in line with the priority list developed in Step 3 or specify his reasons for remaining outside the consensus.

From response Number 4, a list of subject items will be incorporated for use in the fluid power course at Cameron University.

I hope that you will agree to participate in this effort to update and upgrade technician education. This is an excellent opportunity for us to improve communication between industry and education. Thank you for your assistance.

Sincerely,

Jim Hysaw
Curriculum Consultant
Design Drafting Technology
Cameron University
Lawton, Oklahoma 73505

CORRESPONDENCE SHEET NO. 1

Please list up to five possible items to be included in a Design Drafting Technology Fluid Power course. No order of importance is required.

EXAMPLE: A possible item might be: "Study the flow of fluids in pipes."

LIST YOUR RESPONSES BELOW

<u>NUMBER ONE</u>:

<u>NUMBER TWO</u>:

<u>NUMBER THREE</u>:

<u>NUMBER FOUR</u>:

<u>NUMBER FIVE</u>:

A self-addressed stamped envelope has been provided for the return of this sheet.

To facilitate the remaining Delphi mailings, please check to see that I have used your correct mailing address. Please make any corrections and write them in the space below.

APPENDIX C

FOLLOW-UP MEMORANDUM TO

DELPHI CORRESPONDENCE

SHEET NUMBER ONE

CAMERON UNIVERSITY ★ LAWTON OKLAHOMA ★

Lawton, Oklahoma

DATE: July 7, 1978

MEMORANDUM TO: Fluid Power DELPHI Participants

FROM: Jim Hysaw, Curriculum Consultant

SUBJECT: DELPHI Correspondence Sheet Number One

On June 13, I mailed you correspondence sheet number one for identification of items to be included in a Design Drafting Technology Fluid Power course. This memorandum is to remind you that this information is very valuable to us and your participation is important. If you have not already completed correspondence sheet number one, please fill out the enclosed correspondence sheet and return it immediately. This information is needed in order for us to construct correspondence sheet number two and further the study.

APPENDIX D

TRANSMITTAL LETTER AND DELPHI

CORRESPONDENCE SHEET

NUMBER TWO

Lawton, Oklahoma

Thank you for completing the first of three correspondence questionnaires. I appreciate your cooperation in helping us identify course items for fluid power. The initial results look extremely promising. I hope that you will continue to assist us by completing correspondence sheet number two.

Correspondence sheet number two contains the items recommended by you and others for inclusion in an introductory fluid power course. In order that we may determine the most important items, we are asking you to rank them on a six point continuum. Please keep in mind that you are working with course content, not courses to be included in a curriculum.

The highest ranked factors chosen by you and the other DELPHI participants will be given priority in the course structure. Therefore, consider carefully those items you think should be included.

I would again like to thank you for your time and effort. A quick response to correspondence sheet number two will be greatly appreciated.

Sincerely,

Jim Hysaw
Curriculum Consultant
Design Drafting Technology

CORRESPONDENCE SHEET NUMBER 2

Below are the items that you and others suggested that we utilize in a Design Drafting Technology fluid power course. In order that a priority can be assigned to essential course items, we are asking you to rank each factor on a six-point continuum, ranging from the most important (5) to no importance (0).

Please be selective in choosing those items you consider as most important for the fluid power course.

EXAMPLE:	Place (x) in appropriate section No Importance — Most Important
1. Conservation of Energy, Bernoulli's Equation	/ / / / /X/ / 0 1 2 3 4 5
2. Buoyancy, Force on Submerged Surfaces	/ /X/ / / / / 0 1 2 3 4 5

	No Importance — Most Important
1. Application, design of a complete hydraulic system	/ / / / / / / 0 1 2 3 4 5
2. Study the properties of various fluids - compressibility, Boyles law, etc.	/ / / / / / /
3. Fluid power symbols & standards	/ / / / / / /
4. Materials - strength, workability, heat treating, elastomers, plastics	/ / / / / / /
5. Basic principles of pressure and volume controls	/ / / / / / /
6. Valves - check valves, flow control valves, directional control vavles, relief valves, reducing valves, counter-balance valves, one-two-three and four-way valves	/ / / / / / /

		No Importance — Most Important
7.	Heat generation in hydraulic systems	/ / / / / / / 0 1 2 3 4 5
8.	Good design practices - filtering, heat build-up and removal, vibration control, design maintainability	/ / / / / / /
9.	Sizing of piping, lines, and components	/ / / / / / /
10.	Principles of actuators	/ / / / / / /
11.	Basic hydraulic components and their function	/ / / / / / /
12.	Preparation of plumbing layouts - selection of fittings, line routing, mounting	/ / / / / / /
13.	Principles of various types of pumps	/ / / / / / /
14.	Special purpose circuits - regeneration, etc.	/ / / / / / /
15.	Electrical interface for hydraulic system controls	/ / / / / / /
16.	Study of fluid flow - orifices, pipes, etc.	/ / / / / / /
17.	Study of fluid statics	/ / / / / / /
18.	Fluid logic circuit	/ / / / / / /
19.	Speed controls	/ / / / / / /
20.	Hydraulics	/ / / / / / /
21.	Introduction to ASME pressure vessel codes	/ / / / / / /
22.	Introduction to ANSI piping codes	/ / / / / / /
23.	Single line isometric drafting	/ / / / / / /
24.	Pipe and fitting drafting	/ / / / / / /

	No Importance	Most Important
25. Welding symbols and AWS standards	/ / / / / / / 0 1 2 3 4 5	
26. Physics	/ / / / / / /	
27. Basic pneumatics	/ / / / / / /	
28. Industrial shop processes	/ / / / / / /	
29. English	/ / / / / / /	
30. Kinematics	/ / / / / / /	

If we have somehow missed a factor that you consider important, please write below the factor, its ranking, and your reasons for considering the factor:

1. / / / / / / / 0 1 2 3 4 5

REASON:

---

2. / / / / / / / 0 1 2 3 4 5

REASON:

COMMENTS:

APPENDIX E

TRANSMITTAL LETTER AND DELPHI

CORRESPONDENCE SHEET

NUMBER THREE

CAMERON UNIVERSITY ★ LAWTON OKLAHOMA ★

Lawton, Oklahoma

This study, making use of the DELPHI Technique, has been very successful and your cooperation has been instrumental in this success. A ranking of the course items is presented as the last step to complete your participation in the study. The third mailing is provided for the purpose of your evaluating the items in relation to their rank order. Please return correspondence sheet number three as soon as possible.

On behalf of Cameron University, I would like to express our gratitude for your time and assistance in establishing the course items for fluid power. Your individual comments have been very helpful in determining current industrial needs for fluid power in Oklahoma.

Upon completion of the study, I will send you the results along with a list of the types of industries which participated and a summary of your individual comments.

Thank you again for your time and assistance.

Sincerely,

Jim Hysaw
Curriculum Consultant
Design Drafting Curriculum

CORRESPONDENCE SHEET NUMBER THREE

Below are the course items you and others ranked with respect to their priority in a Design Drafting Technology fluid power course. Each item was ranked on a six-point continuum from no-importance to most importance. Those factors with the highest group averages are considered as most important and appear first below. The remaining items are listed in rank order according to importance.

Examine these ranked items and place an 'X' in the blank beside each item that you feel should be placed significantly higher or lower. Use the space provided at the end of this correspondence sheet to indicate each item that you believe should have a revised priority and your justification for the change.

RANK NUMBER	COURSE CONTENT ITEM	GROUP AVERAGE
1.	Application, design of a complete hydraulic system	4.5 ___
2.	Basic hydraulic components and their function	4.2 ___
3A.	Sizing of piping lines and components	4.1 ___
3B.	Hydraulics	4.1 ___
4.	Basic principles of pressure and volume controls	4.0 ___
5.	Valves - check valves, flow control valves, directional control valves, relief valves, reducing valves, counter-balance valves, one-two-three and four-way valves	3.9 ___
6.	Fluid power symbols and standards	3.7 ___
7.	Basic pneumatics	3.6 ___
8.	Good design practices - filtering, heat build-up and removal, vibration control, design for maintainability	3.5 ___
9A.	Study the properties of various fluids - compressibility, Boyles law, etc.	3.2 ___
9B.	Study of fluid flow-orifices, pipes, etc.	3.2 ___

10.	Principles of various types of pumps	3.1 ___
11.	Principles of actuators	3.0 ___
12.	Heat generation in hydraulic systems	2.9 ___
13.	Materials - strength, workability, heat treating, elastomers, plastics	2.8 ___
14A.	Electrical interface for hydraulic system controls	2.6 ___
14B.	Preparation of plumbing layouts - selection of fittings, line routing, mounting	2.6 ___
14C.	Introduction to ANSI piping codes	2.6 ___
15A.	Fluid logic circuit	2.5 ___
15B.	Speed controls	2.5 ___
15C.	Physics	2.5 ___
16.	Introduction to ASME pressure vessel codes	2.4 ___
17.	English	2.3 ___
18.	Special purpose circuits - regeneration etc.	2.2 ___
19.	Industrial shop processes	2.1 ___
20A.	Study of fluid statics	2.0 ___
20B.	Single line isometric drafting	2.0 ___
20C.	Pipe and fitting drafting	2.0 ___
21.	Kinematics	1.9 ___
22.	Welding symbols and AWS standards	1.6 ___

The following items were added to Correspondence Sheet Number Two by one of the participants who gave ghem an importance of (5). Please consider these items and assign them a rank in relation to those items listed.

Quantity and pressure drops through orifices	/ / / / / / / 0 1 2 3 4 5
Orifice coefficients and different types	/ / / / / / / 0 1 2 3 4 5

If you agree with the Rank Order of the items listed, please sign below.

____
(Signature)

If you do not agree with some of the orders write the rank number and the justification as to why you feel this course item should receive a lower or higher ranking.

RANK NUMBER _______
REASON FOR RANKING CHANGE:

RANK NUMBER _______
REASON FOR RANKING CHANGE:

____
(Signature)

VITA

Jimmy Lee Hysaw, Jr.

Candidate for the Degree of

Master of Science

Thesis: A STUDY OF INFORMATION ELEMENTS FOR INCLUSION IN AN INTRODUCTORY FLUID POWER COURSE FOR A DESIGN DRAFTING PROGRAM

Major Field: Technical Education

Biographical:

Personal Data: Born in Ventura, California, July 13, 1954, the son of Mr. and Mrs. Jimmy Hysaw.

Education: Graduated from Lawton High School, Lawton, Oklahoma, in May, 1972; received a certificate of Design Draftsman from Great Plains Area Vocational Technical School in May, 1972; received an Associate of Science degree in Design Drafting from Cameron University in 1974; received a Bachelor of Science in Technical Education degree from Oklahoma State University in 1976; completed requirements for a Masters of Science degree at Oklahoma State University with a major in Technical Education in December, 1978.

Professional Experience: Designer and Surveyor, Hendrick and Sons Engineering, 1971-76; Draftsman and Surveyor, Engineers for Agriculture, 1974-75; Party Chief Surveyor, Mantle & Associates, 1975-76; Graduate Assistant, Oklahoma State University Technology Department, 1976-77; Graduate Assistant, Oklahoma State University Department of Occupational and Adult Education, 1976-77; Mechanical Engineer, Burtek, Incorporated, 1977-78; Professor, Seminole Junior College, 1978.