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Plans for farm buildings should efficiently explain information about their construction. User understanding and actual use made of plans has received little study. The format used for plans should enhance their wider use and greater satisfaction by individuals concerned with constructed buildings.

This study addressed two research questions: (1) Is there a relationship among typical formats used for portraying a farm building plan and understanding the information therein by typical users, and (2) what components used in the portrayal format of farm building plans are preferred by typical users?

A pole frame building plan was developed that used orthographic, perspective and exploded drawings. Twenty questions about this plan were asked a sample of 278 typical users in 20 different North Dakota locations. Eight additional questions queried user preferences for plansheet color, size, extent of written explanation on use of the finished building and use made of plans.

The study determined that users of plan formats employing pictorial drawings (perspective and exploded) gained a better understanding of the plan than those who used the orthographic format. Typical farmer, lender and county agent plan users gained a better understanding in less time than did younger students. Plan understanding and time needed for understanding a plan was unaffected by the indicated carpenter experience or training on planning farm buildings by users. Plan understanding was affected by the relationship of detail size, clarity and plan format.

Typical users of farm building plans preferred a minimum explanation on the plan about use of the finished building. Plansheets were preferred with blue lines on white 11 x 17-inch paper. The use of plans for actual construction was secondary to their use for planning.

THE EFFECT OF FORMAT ON THE UNDERSTANDING AND PREFERENCES FOR SELECTED COMPONENTS BY TYPICAL USERS OF FARM BUILDING PLANS

BY

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INTRODUCTION

The primary purpose of this study was to explore the effect of format on understanding a typical farm building plan by typical plan users. These formats included a standard orthographic projection and two different perspective projections--one an interior, single-point perspective and the other an interior, single-point, exploded perspective.

A second purpose of this study was to explore typical user preferences for selected format components used with typical farm building plans. These format components included color of lines, size of plansheet and extent of written information included with the plan.

The uses made of plans by typical users can be a guide to effective plan preparation. The development of effective plans can enhance their use and provide for meeting the desired needs of practical and functional farm building construction. The overall goal is to have a building plan effectively convey needed information to all those involved with its construction.

Background

One activity of the Cooperative Extension Service throughout the nation is the development and distribution of plans for farm buildings. These building plans are the vehicles for pictorially communicating information about research and experiences on the design and construction of farm buildings or related equipment developments. Building plan use by the Extension Service is comparable to their use of circulars and other written materials for disseminating information on other subjects such as crop chemical application, selection of garden varieties, animal care and use of farm record systems. Rather than the written word, however, a building plan employs a system of lines and symbols that are organized into drawings. The pictorial communication technique conveys a maximum amount of information on a unique, complex subject (Giesecke, et al.,1974).

Consumers of building plans distributed by the Extension Service include builders, engineers, architects, and educators. However, the total audience includes homemakers, farmers, lending agencies, other agri-business persons and related groups (Gustafson, 1967).

Many individuals are not conversant with the conventions used on architectural and mechanical drawings (French and Vierck, 1972). The array of different lines, symbols, and views used to portray the different parts of

a building can be confusing, particularly to persons who infrequently use plans. The illustration conventions employed with plans are a specialized language that is seldom encountered by anyone other than those who regularly work with plans and planning (Wallach and Hepler, 1981). As with verbal communication, persons who are conversant with the language can associate different connotations to the symbols used (Barnhart, 1976). Misunderstandings related to plan "language" can cause building planning and construction problems. Grooming the plan format to enhance understanding can aid planning and minimize problems.

To gain the interest of potential users and promote their successful employment, building plans as documents should instantly attract the readers' attention and concisely show the concept of the completed building. In the simultaneous and subsequent utilization processes the plan needs to convey and explain explicitly the details of the separate building parts and the "how-to" of practical and safe assembly of the building (Lessiter, 1983). The required attention to and subsequent successful use of plans will be ignored if their appearance is formidable and disheartening.

The technique for prompt attention by typical users is increasingly being challenged. For example, the audio-visual experts for newspapers, magazines and

television continue to intensify their presentations with glowing colors and bursts of action that stimulate human senses. This "coddling" progresses along with a decline in general reading skills (Copperman, 1978; Education Commission of the States, 1981). The presentation format of farm building plans has not received attention comparable to that for other media. Farm building plans too must be prepared as presentable and understandable as possible so to compete with the other media efforts that similarly demand the users attention.

Different documents represent the variety currently categorized as farm building plans by interested audiences. The word "plan" has a broad context (French and Vierck, 1972). For example, a building plan can be a quick, simple sketch, drawn on a piece of board by the county agent with the owner on hand to make his or her direct input. Or a young vocational agriculture student with limited drafting experience will draw a "plan" of the family dairy barn simply using a straightedge and plain writing paper. At the other extreme are building plans that portray a multistory barn with many enlarged details and scaled drawings on from two to 20 large sheets of special paper. Such complex drawings result from many days of contemplation and preparation by trained, experienced professionals. Often this involves consultation with other disciplines, such as the plant or

animal sciences. Then too, some commercial company may adapt such an Extension Service-developed plan and modify its form to meet their public's need. Though this commercial plan may represent the same grain storage building, swine farrowing barn or whatever, the building plan is presented in yet another format that has stronger emphasis for that commercial interest.

Whether prepared by professionals or others, each farm building plan will consequently differ in its format, amount of content, the size to which it has been drawn and the illustration technique used. Most building plans are portrayed using basic orthographic projection techniques. These usually show a floor plan, elevation, cross-section and some enlarged details of selected parts of the building (Giesecke, et al., 1974). Plans may also include alternative cross-sections, one or more wall details, a pictorial view of the building interior or exterior, a materials list, written instruction about the use of the building plus other related data and information (French and Vierck, 1972; Wallach and Hepler, 1981). The varied formats and portrayal arrangements used with farm building plans supplied through the Extension Service and other sources result from different authors and preparation origins.

As a result of encountering different plan formats, illustration techniques, sizes of drawings, uses of notes,

and related components, building plan users can be distracted, confused and disheartened about using plans (Kennedy, 1974). The viewer's capacity to comprehend quickly what building plans are attempting to explain is diminished with lack of clarity and consistency. This "consistent inconsistency" hinders the enhancement for continued or increased use of building plans. The "massaging" by commercial firms and others compounds any standardized format promulgated by the Extension Service. Format guidelines would be helpful in presenting farm building plans more uniformly which in turn would cultivate their ease of recognition and use.

Along with the related questions which indicate a lack of communication of construction detail by farm building plans (or more likely as a result of it) are varied forms of farm building failure. These failures relate back to detrimental changes made in plans during construction. For example, increasing the recommended spacing of rafters can seriously affect a building's life and lead to premature collapse. There are also functional types of failures, such as erroneous door sizes or locations, incorrect concrete floor slopes for efficient drainage, installment of substandard materials and use of finishes that cause dissatisfaction with a new building's appearance or construction (Lessiter, 1983). A plan should effectively translate professional recommendations and help prevent these types of misunderstandings.

A further complication with understanding farm building plans is the infrequency that farm building planning and construction are done (American Society of Agricultural Engineers, 1981b). In any individual case, when farm building construction is accomplished, rarely is the same type of building project repeated. On a particular farm a new cattle barn may be followed several years later by a new shop, grain storage, residence or other type of building. In the meantime, available building materials have changed along with construction techniques, investment required, available building shapes, typical sizes and associated technology. Solar energy application is an example of a recent change. Farmers, advisors and builders find such changes in recommendations difficult to replace information which was previously utilized.

In addition to such uncontrollable input changes, other changes also continue to evolve which affects new building planning. For example, certain types of farm buildings (i.e., swine barns, milking parlors, potato storages, etc.) continue to demand more sophisticated environmental controls, manure handling, feeding and animal handling equipment. As an intricate part of the building itself, this equipment is pertinent to its successful operation. Fresh air for mechanical ventilation system operation, for example, is often drawn

through an adjustable ceiling inlet from an overhead attic space. Such incorporated components increase the need for an up-to-date plan that readily communicates the necessary information for constructing a complete facility (Midwest Plan Service, 1980).

These aspects of unfamiliarity with plan language, infrequent use of plans, variations in plan formats, changing technology, and need for attractiveness form the background for a need to explore the effect of format on the understanding of farm building plans by typical users. Exploration of different formats and preferences for related components can identify useful plan preparation information.

Significance of the Study

The identification of more understandable format items and related components can be utilized in the preparation of future farm building plans to aid their effectiveness. This information can be applied by organizations who prepare plans, such as the Midwest Plan Service (MWPS), the United States Department of Agriculture Cooperative Farm Building Plan Exchange Service (CFBPES), farm building suppliers, construction persons, teachers, and others. The application of more understandable format should provide typical users of plans more expeditious use of information about farm

building construction. Improved understanding should ultimately reduce construction problems, personal animosities, related costs and prevent building failures.

The study should broaden the future applications of planning and uses for building plans. If plans can provide more effective instruction, there should be less need for more cumbersome verbal or written instruction about building construction. Improved understanding should foster expanded plan use. This in turn can increase typical user familiarity with the language and interpretation of plan messages and satisfaction with the finished product.

Delimitations of the Study

A study related to learning or understanding can involve many facets and factors (Travers, 1979). It was not the intent of this study to explicitly review every item that might be related to understanding farm building plans. Rather, since there appeared to be little empirical information available, this study was designed to explore the more apparent format variations that could affect plan understanding.

The study focused on the understanding of a plan for a typical farm service building such as that used for housing livestock, machinery or for crop storage. Pole-frame construction is commonly used with these types

of facilities (Midwest Plan Service, 1980). Although a strong relationship should exist, study resources were insufficient to include consideration of other types of construction such as that used with large, complex, human occupancy type facilities (e.g., hospitals, public schools, churches, electrical generation plants etc.).

The purpose of a farm building plan is to promote functional, practical, and safe farm building construction. Such an overall inclusive purpose requires years to satisfactorily evaluate from an engineering perspective that includes rafter size, use of braces, number of nails, foundation anchorage, etc. The longevity of a particular type of farm building construction encouraged by a particular plan was beyond the scope of this study.

Plans for farm buildings are used by different audiences in different ways (Gustafson, 1967). This study involved audiences who typically but infrequently use farm building plans. The symbols and language used with plans should have been relatively strange to them. In-depth analysis of selected audiences would be another meaningful study. Although secondary and post-secondary vocational agriculture teachers, for example, use farm building plans they usually have specific training in construction and more regularly use plans. For this reason they were considered an atypical audience. Their reactions and

insight to plan format and use from the perspective of teaching deserves special consideration.

Although other items may be as important, it is essential that the viewer of a building plan relate the two-dimensional drawing to a three-dimensional object (Madsen, 1972). This involves combining the dimensions of length, width and height. The grasping of these three basic dimensions is critical to the understanding of a building plan and was fundamental to this study. Because each person has reference to prior and different experiences, each person "sees" differently. For example, different observers of a picture are each correct but each notices slightly different portions of the picture (Kennedy, 1974). Although this aspect was involved it was beyond the scope of this study to include the process of perception, implications of memory, receiving processes, problems with dyslexia, lighting levels, meeting group effects, eyesight and other interferences to thought pictures (Mortenson, 1979).

Drafting is an art that follows prescribed guidelines (French and Vierck, 1972). It was not the intent of this study to investigate the techniques of art or drafting. Rather the study was to determine the understanding of a completed plan that employed typical formats and/or techniques that are commonly used to illustrate building plans.

Definition of Terms

Prior reference has been made that building plans and planning have a specialized language. The terminology used can be strange and confusing, especially to those who infrequently use the terminology such as users of farm building plans. Some common terms are defined here. There are numerous other terms used for the illustrations and preparation of building plans. Since passing reference is only made to some of these in this study, space is not devoted to their explanation. The reader is referred to such references as Burke, Dalzell and Townsend, 1955; Muller, 1967; Giesecke, et al., 1974; Guerard, Walston and Winegar, 1970; Midwest Plan Service, 1980; Putnam and Carlson, 1974; Wallach and Hepler, 1981.

Agricultural engineers are graduate professionals who apply engineering principles and practices to agriculture. They usually are involved with planning and the design of farm buildings (American Society of Agricultural Engineers, 1981a; Midwest Plan Service, 1980).

Architecture is the art, science and/or practice of designing and constructing buildings or structures, especially habitable ones (Woolf, 1975). Architects are particularly concerned with the exterior appearance and functional interior organization of a building.

Architectural and mechanical drawing is done with the aid of instruments, including scales, triangles, compasses

and straightedges. Mechanical drawing has more application to machinery while architectural drawing has more to do with buildings (Giesecke, et al., 1974).

Building has reference to a roofed and walled structure constructed for permanent use (Woolf, 1975). Buildings are constructed rather than built.

Design of a building involves preparation of preliminary sketches, working drawings or detailed plans which evolve into an outline showing the main features of something to be constucted (Woolf, 1975).

Draftspersons are artists who excel in architectural or mechanical drawing and who sketch and draw plans under the direction of an architect or engineer (Burke, Dalzell and Townsend, 1955).

Engineering is the application of science and mathematics by which the properties of matter and sources of energy in nature are made useful to humans in structures, machines, products, systems and processes (Woolf, 1975).

Format is the size, shape and general makeup of something drawn. In the general appearance of a plan, for example, this would mean the page layout, page size, its shape, type used or makeup of the words and size of lines used (Woolf, 1975).

Graphics pertains to the use of graphs, diagrams, curves, symbols or devices used in writing or printing to represent sound or convey meaning (Woolf, 1975).

Graphic arts is the art of representation, writing, decoration or printing on flat surfaces together with associated techniques and crafts. Technical illustration is a growing part of graphic arts and coordinates illustration with written instructions (Mills, 1970).

Isometric drawing is one type of axonometric projection that depicts three sides of an object that has been rotated and inclined upward, usually 30 to 45 degrees, on a plane from a parallel position to give it a pictorial appearance (Giesecke, et al., 1974).

Oblique projection is similar to orthographic projection except the object is viewed oblique to (or at an angle) and at an infinite distance away from a direct frontal, orthographic view (Giesecke, et al., 1974).

Orthographic projection refers to the portrayal scheme that shows, in two dimensions, the views of an object as it would appear to an observer standing directly and at an infinite distance away from the side being viewed (Giesecke, et al., 1974). Multiview orthographic projection is typically used with plans.

Perspective projection is a form of pictorial drawing representing an object in three dimensions, very much as the lense of a camera records an image on a film. The perspective portrayal of the object is considered to be made at a finite distance from the object which results in a converging of the object outlines (Burke, Dalzell and Townsend, 1955; Giesecke, et al., 1974).

Pictorial drawing is a general term referring to drawings that show the appearance of several faces of an object in one view (Giesecke, et al., 1974).

Picture is a general term that is more synonymous with photographs or paintings and which show more variations in coloring or shading than do drawings, sketches or plan illustrations (Woolf, 1975).

Plan, a generic term, can refer to a process or an instrument (Woolf, 1975). Hereinafter a farm building plan refers to a drawing or a form on a plane surface that is used for conveying information about a farm service building.

Pole-frame construction refers to the use of pressure preservative treated poles embedded in the soil to provide the support framework for walls and roof of a building. This type of structure avoids the use of a concrete foundation and simplifies construction. Horizontal framing girts of dimension lumber are attached to the poles for siding support. Girders of larger dimension lumber are attached to the tops of the poles to support the roofing rafters. Purlins are dimension lumber framing members installed over or between rafters to support the roof (Midwest Plan Service, 1980).

II. REVIEW OF RELATED LITERATURE

Introduction

A review of the literature yielded no direct information about studies on understanding farm building plans. The current practices used for portraying building plans have apparently evolved based on experience and individual preference. Closely-related information was available on several aspects that could apply to understanding farm building plans. These are reviewed from that standpoint.

Pictures and Seeing

The aphorism "A picture is worth a thousand words" is frequently heard.[1] Although pictures are somewhat different from building plans, a review of the literature indicated that the understanding of pictures had received some study (Gibson, 1960; Gombrich, Hochberg and Black, 1970; Kennedy, 1974; Novitz, 1977; Worell and Stilwell, 1981). These observations and findings provided

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[1] Often credited to Chinese origin and Confucious in particular, the original statement, "One look is worth a thousand words," was actually written by Fred Barnhard and first appeared in the December 8, 1921 issue of Printers Ink, (Stevenson, 1948).

implications that applied to understanding drawings. In his book, Kennedy (1974) explained:

> The idea that pictures deserve scientific experimental investigation is very recent; an experimental psychology of pictures is barely underway, and only a few studies provide anchorage in a sea of issues in the psychology of pictures. The issue of this book being the way pictures provide information. . . . By and large, the studies show pictures can be quite accurate with just minimal instructions to the subjects. (p.12).

How we see is pertinent to the success and use of pictures. Barnhart (1976) summarized the operations of the major senses in communications. She explained that the eye does not produce pictures in the brain but rather it supplies the brain with chains of electrical impulses which in the brain represent objects. The process of producing pictures is based on such things as: experience with similar objects, emotional state, physical aspects like illumination and changes in the object being viewed. Sensing beyond hearing, taste, smell or touch, the eyes are the long-range sense organs and the undisputed sense for perceiving color.

When different persons view the same object, it is perceived differently due to the pattern or organization of what is seen (Rothkopf,1976). The classic Rohrschach test, in which interpretation is made of an ink blot on paper, is an example of how different persons can see different things although viewing the same object (Claus

and Claus, 1976). Then too, persons asked to sketch an object, such as a car or barn, will each draw something a little different in size, shape, and clarity. Each will also need a different length of time to complete their sketch. A series of studies by Gollin, for example, depicted outline drawings of familiar objects such as a car or dog (Kennedy, 1974). Segments of the object drawings were gradually erased until bare hints of the configurations remained. It was found that object recognition was easier for adults. The amount of outline needed in order to recognize the objects that were depicted decreased gradually from the youngest subject (five years old) to the adults.

Portrayal

How an object is portrayed or illustrated affects understanding. In a preliminary study, Ryan and Schwartz (1956) illustrated three objects, each in four different positions, in four different ways: (a) photographs, (b) shaded drawings, (c) line drawings, and (d) cartoon or caricature-type drawings. Slides of these 48 illustrations were projected on a screen at different time intervals to subjects. The time interval exposures were increased from being too brief until the correct judgement was made. The cartoon or caricature representations were perceived in the shortest time exposure, the line drawings

the longest times. Photographs and shaded drawings required about equal times and fell between line drawings and cartoons.

Kennedy (1974) described a related study of pictures by Perkins of how caricatures of well-known people were more easily recognized. Another study of how people's faces were pictured in accurate projection or in cartoon form is reported by Gibson (1960). These study results were questionable, however, in that faces were different than objects. Object expression is fixed while facial features change from one moment to the next.

When solving a visualization problem, such as interpreting a farm building plan, the viewer works from what is known and extrapolates toward the unknown. The use of pictorial drawings and models can aid this process (Bjorquist, 1966; Muller, 1967). Although pictorial drawing is proclaimed as more understandable by lay persons, orthographic projection in the third quadrant is a common technique of plans illustration in the United States (Giesecke, et al., 1974). Popular homecraft magazines employ pictorial projection techniques to illustrate construction. This is comparable to that used with the growing practice of technical illustration (Mills, 1970). Perspective projection employing one or more points on a horizon have been employed with farm building plan illustrations (United States Department of

Agriculture, 1970). Isometric drawing, though used, has not been as common because of the distortions that result when illustrating a large object such as a building.

Lettering

Written words are often an integral part along with lines for explaining drawings. The technique used for their display or format affects the attention received and the conveyed understanding (American Association of Agricultural College Editors, 1976). Road maps, sewing patterns, daily weather maps and cartoons are corollary ways to presenting information with words, lines and drawings as is done with farm building plans. The detailed, step-by-step procedures used with clothing construction is not usually considered a requirement with farm building plans. The symbolized drawings and maps usually employed with daily weather reports serve to familiarize viewers with a two-dimensional visualization technique. The same is true for drawn advertisements with various styles of lettering in newspapers and magazines. This subtle kind of education of words with drawings should influence how people understand farm building plans. Essential to building plans, however, is the visualization of a third dimension.

A sign or map is only as legible or capable of being read and deciphered as the letters and numerals used for

its message. To be effective a road sign must in a very few seconds attract attention and convey its message (Collins, 1982). Sign legibility is determined by: legibility of individual letters and numerals used, letter height, proportion and spacing, the relationship of the size of the displayed information and the viewing distance, color combinations, illumination and viewing angle (Claus and Claus, 1974). The familiarity of the words themselves and their positions affect readability as does the shape, thickness and spacing of letters in the words. Plain letters, narrowed at thick points (i.e., joints in t, h, e, g, etc.) and spaced at one-half the width of "o" are best (Claus and Claus, 1976). The formula given for machine panel marking word size by Peters and Adams (1959) can be a guide for calculating word letter heights on drawings. For a 16-inch viewing distance with favorable lighting, a letter height of 0.185 inches is suggested.

Color

Different colors can influence a viewer. Colors affect how the eye focuses and sees (Claus and Claus, 1976) Yellow and white are more easily focused, then red, green and, finally, blue. Different color combinations of print and background have been studied (Claus and Claus, 1976; American Association of Agricultural College

Editors, 1976). Black letters on white background generally are among the most legible or readable. White letters on blue background and black letters on yellow are most readable as determined by threshold differences, short exposures and reading speed. This is exemplified by their use on highway signs.

The following combinations of colors are given in their general decreasing order of legibility or capability of being read or deciphered (American Association of Agricultural College Editors, 1976):

1. Black on yellow
2. Green on white
3. Red on white
4. Blue on white
5. White on blue
6. Black on white
7. Yellow on black
8. White on red
9. White on green
10. White on black
11. Red on yellow
12. Green on red
13. Red on green
14. Red on blue

These relationships have general application, however, and would vary with individual preferences and viewing conditions as has been previously referred to here. For example, Claus and Claus (1974) referred to color combinations and reading speed that used black letters on white as a standard. Other color combinations decreased in legibility from that standard.

Farm building plans are usually black lines and lettering on white or nearly white paper. Blue lines and

lettering on white are also frequently used (Midwest Plan Service, 1957; Hansen, 1980). This practice of printing blue lines on white is a consequence of the ozalid reproduction process that has been used for copying large sheets of paper and particularly plans (Giesecke, et al., 1974). For years the ozalid reproduction process has commonly resulted in blue lines and lettering on a nearly white paper. An older reproduction process resulted in white lines on blue paper. Hence the evolvement of the term "blueprint." The terms "blueprint" and "plan" have been so synonomously used that now some individuals insist that a building plan (to be a "plan") must have blue lines and lettering on white paper. Advertisers and magazines make a ploy on this facet (Advertisement, 1983).

Sheet Size

Farm building plansheets range in size from 34 x 44 down through 8.5 x 11-inches (American Society of Mechanical Engineers, 1980). Which size is used depends on the subject, the extent of portrayal desired and the preparer of the plan. Generally the smaller sheet is preferred to minimize awkwardness when the plan is used. There is some minimum size of sheet and portrayal, however, that will convey the intended message to the user. No study has apparently been made on what is this minimum size.

Plan Content

County agents and other educators disseminate research information to farmers and other consumers in a variety of ways. Foremost among these methods includes the spoken and written word (American Association of Agricultural College Editors, 1976). A plan can be viewed as the report of research on farm buildings (Giese, 1966). Traditionally, professional agricultural engineers and architects have conducted "research" on farm building construction and have reported their findings in the form of plans. These plans are used for various purposes by farmers, suppliers, builders and others to interpret essential components of the researched building.

Drafting practices in the industry have gradually evolved. Uniform techniques have been developed through the American Standards Association.[2] Some of these adopted standards have not been regularly updated (Wimsatt, 1983). Other related handbooks have been developed to foster more standardized symbol use with building plans. For example, the Architectural Graphics Standards (Ramsey and Sleeper, 1970) is described as ". . . a source book and standards guide and not a book of experimentally exotic or sophisticated techniques. It illustrates current and proven practice."

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[2] Now the American National Standards Institute (ANSI), 1430 Broadway, New York, N. Y. 10018.

In the "Foreword" to Section 4 of American Drafting Standards Manual (American Society of Mechanical Engineers, 1957) a comprehensive review is given about developments in the 1920s of a standard for engineering drawings.

> The objective was to produce a comprehensive standard, based on well-established conventional practices to satisfactorily fulfill industry's most exacting fundamental requirements.

The "Foreword" also relates that:

> It is expected that users groups will supplement the provison of the Y14 Standard Practices with varying degrees of simplification, discreetly decided upon at individual user levels in keeping with the type of service for which drawings are prepared.

Most drafting textbooks do not follow nationally recognized drafting standards. Rather they use a combination of current and obsolete industrial standards (Ryan, 1974). As they gain more experience, draftspersons and designers of graphic materials develop particular styles and produce their own renditions. Similar to other artists, individual techniques are cultivated.

Visits with engineers, draftspersons, architects and others daily involved with preparing plans brought forth reasons for variations in plan format, content, type of detail and sheet size (Glass, 1980; Hansen, 1980; Pedersen, 1982; Ross, 1983). Ready assent existed that there was no one best way to portray a building plan. A need was suggested to illustrate building plans

differently for different audiences. Conversely there seemed little agreement on a portrayal technique to satisfy the majority of users. Simplicity, clearness and realism are constructs quickly endorsed. Methods to achieve these, however, just as quickly diverge. There seems to be as many ways to effectively illustrate a plan as there are persons doing it (Pedersen, 1982). Ultimately it is the farm owner who needs to recognize what constitutes "good" design because he/she will need to make the building function (Henderson, 1964).

The elements of successful design are not well understood (Hurlbut, 1977). Although simplification and individuality in a building plan presentation can promote understanding (Herberts, 1971), an adherance to certain symbols and conventions is needed for succinct communication within the building industry (F. W. Dodge Division, 1981). Such uniform standards have special significance with international trade (International Standards Organization, 1982). The ANSI standards (i.e., ASA Y14.4-1957, "Pictorial Drawing") (American Society of Mechanical Engineers, 1957) are ones that have developed for building plans in the United States (Blankenbaker, 1982; Hecker, 1982). No specific study seems to have been done, however, to support a standard format of a typical farm building plan or of any preferences for illustrating a plan for maximum receptiveness, understanding or use

(Carter and Foster, 1941; Henderson, 1964; Glass, 1980; Hansen, 1980; Pedersen, 1980).

In addition to professionally prepared plans there are other sources of building plans which will likely use a different format. For example,

> The agriculturalist has a different purpose in mind than the artist or architect when he makes a sketch. His purpose is to give a general idea of the appearance of a building or piece of equipment, together with sufficient data on dimensions and size of material so that he or his carpenter can reproduce it at a later time, or his purpose may be to make a record to be translated later into a working drawing (Wooley, 1953).

Such plans drawn by agri-business persons are depicted as they are "seen" and irrelevant information is, at least in the person's mind, excluded. This suggests that more detail than necessary may be portrayed on farm building plans. Drawings used by industry are encouraged to be streamlined to save employee time and labor (Herberts, 1971).

The readability of building plans could be considered as similar to the readability of publications. This potentially could aid effective development of new materials. A study of the readability of carpentry instructional literature, for example, found that eleventh- and twelfth-grade carpentry students required supervision to translate the skills described (Thornton, 1977). Ancillary studies of the preparation and use of

selected 4-H project literature (Carter, Zimmerman, and Gruber, 1977), illustrated news releases (McGlashon, 1981), and an Extension circular (Nehiley and William, 1980) identified strengths and weaknesses in illustrative and verbal content of respective extension educational materials. Recently, for example, studies using Extension audiences have found that illustrated publications have a positive affect on comprehension by limited-resource audiences (Nehiley, Stephens and Sutherland, 1982). A related study about the use of pictorial information to support written, scientific instruction indicated there was inconclusive evidence that illustration greatly affected understanding of science education materials by tenth-grade students in biology (Holliday, 1975).

Readability of a document is a function of the reader's interest and experience which are inter-dependent on one another. If interested, one will seek after what one wants or needs and the consequent experience aids proficiency. Stated in another way, we do best what we like to do. This impacts on understanding as an individual's recall is improved by repetition. Usual categories in terms of which readability is normally measured, however, do not account for such factors as organization of the material, nature of the content and the overall format. These items are basic to farm building plans. Rather most readability measures focus on individual words and sentence length (Berelson, 1952).

Since 1958, an educational aids exhibit has been a regular event at the annual meeting of the American Society of Agricultural Engineers. Members of this national professional organization voluntarily submit farm building plans, publications, educational models, visual aids and reports that illustrate successful extension demonstrations each has accomplished during the past year. Entries are placed in respective categories and formally judged by a committee of selected peers (American Society of Agricultural Engineers, 1982). The criteria in the judging form used for the farm building plans exhibit category has varied over the years. The criteria include factors related to appearance, technical design and total content. The form is again being reassessed (Ross, 1983). Interest and experience of judges has annually affected how exhibited plans are appraised. A need exists for identification of basic criteria that can be applied to these appraisals.

The special training which is required to do drawing is logical. This importance was apperceived when drawing was included as the earliest form of vocational training in American public schools in the 1870s (Clarke, 1885; Blauch, 1969). An achievement test developed for drafting further espouses to this requirement (Blum, 1966). Results from a series of comprehensive studies about drafting and design technology program needs exemplified

its technical content (Guerard, Walston and Winegar, 1970). Producing drawings, however, differs from understanding drawings.

Bjorquist (1966) concluded that pictorial drawings were more effective than scale models or no aids in helping beginning students to learn some principles of orthographic projection. Campbell (1969) found no significant difference between an experimental group of high school students using a programmed supplement and a control group taught by the lecture-demonstration method in a pupil's ability to visualize spatial relations and their retention of this ability. Jackson (1970) compared programmed instruction with and without supervision with lecture-demonstration. This study was conducted with college students enrolled in graphic communications. He concluded the three teaching methods were equally effective in terms of initial learning and retention. The transfer of learning from blueprint reading to technical drawing in a post-secondary setting was studied by Cook (1978). A five-hour, self-instructional unit on blueprint reading was completed by an experimental group. This had a significant, positive effect on their blueprint reading performance but had no apparent transfer effect on the learning of technical drawing concepts or psychomotor skills. These and other (Hepler, 1957; Beck, 1966; Walker, 1971) related studies are helpful in

conceptualizing the interferences with understanding building plans.

Basic printed material layout techniques involve providing balanced page appearance, use of proportion, cognizance of the clockwise viewing habit, employment of unity in the total presentation and the overriding principle of simplicity (Nelson, 1978; Foster, 1982). Whether a billboard, newspaper, magazine or farm building plan is being viewed, the viewer's attention is immediately directed toward the top of the object and is then carried over to the right and down. To promote continued observation, balance is provided to the different sizes of illustrations, and a consistent, relative proportion is given to the different drawings on as few possible pages. Utilization of these techniques encourages interest and continued readership which is also needed with farm building plans.

Pictorial drawing is regarded to be the more realistic portrayal motif and is popular with the graphics industry (Muller, 1967; Sluzas and Ryan, 1977; Yobu, 1979). Considered to be the oldest form of written method of communication known to man, the character of pictorial drawing has changed as civilization has advanced (American Society of Mechanical Engineers, 1957). Although pictorial drawing is common, its applications to farm building plans has diminished. Aside from a few, small,

outline type sketches, pictorial drawing was not utilized in any of the seven, new MWPS or nine, new USDA plans prepared during 1979. It is opined that pictorial drawings are time consuming to draw (Mensch, 1982). Orthographic projection in the third quadrant is the more accepted way to portray a building (Giesecke, et al., 1974; Muller, 1967; Teter, 1982).

Technical illustrators are broadening the applications of exploded types of pictorial drawings. This is helping meet the rapidly growing need to administer more and better instruction in an age of burgeoning technology (Mills, 1970; Ingram, 1972). Technical illustration provides the assembly or "how-it-goes-together" illustration with the width, length and height connotation of pictorial drawing (Gibby, 1965). Such applications are widely used in currently popular artisan magazines (e.g., Popular Mechanics) that are competitive and must readily satisfy their readership to stay in business. This technical illustration format blended with the basic layout technique used for written publications reduces the strangness of building plans (Giesecke, et al., 1974).

Use of Building Plans

The literature on building plan development brought out two factors. One was that little user evaluation or research had been done on the actual application or understanding of plans. The other was that a relatively large amount of research had been done on the effective teaching of drafting. It is ironic that some concomitant research was not done between effective teaching and what the effort would later produce outside the classroom (Herberts, 1971).

A survey was conducted on the use of building plans and two planning handbooks prepared through the Midwest Plan Service (MWPS)[3] (Gustafson, 1967). The objectives of that study were to identify who were the users of the MWPS publications and to determine how the publications were used. Data were not collected on the understanding or achievements resulting from the use of the materials. A questionnaire elicited information from plan requestors about their:

1. Occupation;
2. Type and size of farming operation;
3. Reasons for requesting publication;

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[3] The MWPS is an organization of one research and one extension agricultural engineer from each of the twelve, midwest, land grant universities and the United States Department of Agriculture.

4. Satisfaction with publication content;
5. Use made of the publication;
6. Where the requestor learned of the publication;
7. Suggestions for future publications;
8. Judgements on specific sections in a publication.

The selected publications were: (a) Beef Housing and Equipment Handbook,(b) Swine Housing and Equipment Handbook, and (c) all building plans.

From 700 requestors who were sent the questionnaire, 382 (55 percent) responded. Approximately one-half of the respondents were farmers and 20 percent were part-time farmers. The other 30 percent were connected with farming in some way. One-half were livestock farmers, and they wanted the information for planning purposes. Nine percent of the plan users were beginning a livestock operation. Over one-half were satisfied with the information, and about one-third used the books and the plans for actual construction. Recommendations from this study included making periodic follow-up studies on similar MWPS materials and to study selected requestor audiences more in-depth about uses and problems with all MWPS publications. The multiplier effect or "spin-off" where neighbors observe and do from watching what others do, was ascribed to in this study. This supported a claim that farm building plans keep on "working" beyond the actual drawing. No explanation was reported about accuracy of understanding the plan.

A more recent follow-up study about MWPS building plans only was reported by Pedersen (1980). A fairly low percentage of replies was reported. There was no indication of the number of questionnaires sent or of attempts to improve the response rate. About 70 percent of the replies were from full or part-time farmers. The remainder were categorized as educators, agri-business or other. Some 80 percent of these respondents indicated they had wanted information on building layout. About one-half used the plans to do construction themselves, while 14 percent had employed a contractor. Again no measure was made as to the understanding of the information in the plans.

The MWPS continues to develop and supply building plans and planning information. No additional follow-up studies have been reported. Concern about format and material content, however, were again recently reviewed (Pedersen, 1982). Two, similar, regional farm building plan service organizations[4] have developed since about 1970. Neither of these has studied the usage made of its published materials (Hansen, 1980).

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[4] Northeast Region Agricultural Engineering Service, (NRAES), Cornell University, Ithaca, N.Y., and Western Region Agricultural Engineering Service, (WRAES), Oregon State University, Corvallis, OR.

The Canada Plan Service has operated a nationwide farm building plan service similar to the Extension Service's Cooperative Farm Building Plan Exchange Service (CFBPES). The Canadian materials are only evaluated by informal feedback from the provincial Extension Agricultural Engineers (Turnbull, 1981).

A survey was made of state Extension Agricultural Engineers about the number of plans that were distributed through the CFBPES (Cox, 1977). The different uses made of plan contents and the multiplier effect from these exchanged plans were not quizzed. Surveys of plan usage indicated that ten percent of the 360,000 sets of plans distributed for farm service buildings were actually used for construction.

Research Questions and Hypotheses

The underlying question in this study was what effect portrayal format had on the understanding of farm building plans. The first major research question was:

1. Is there a relationship between typical formats used for portraying a farm building plan and understanding the information therein by typical users?

To answer the first major question, the following testable hypotheses seemed appropriate.

Hypothesis I. There is no difference in mean test scores for typical users of a farm building plan portrayed by three different formats (i.e., orthographic projection, perspective or exploded type drawings).

Hypothesis II. There is no difference in the mean test scores by four types of typical users of farm building plans (i.e., farmers, students, lenders, and county agents).

Hypothesis III. There is no interaction among the mean test scores by types of formats and types of typical users of farm building plans.

Hypothesis IV. There is no relationship between the mean test scores and the time needed by typical users to understand a farm building plan and complete the test.

Hypothesis V. The relative size and clarity of enlarged details have no effect on the correct understanding of farm building plans as measured by the scores of key questions by typical users.

The second major research question was:

2. What components used in the portrayal format of farm building plans are preferred by typical users?

To answer the second major question, the following hypotheses were identified:

Hypothesis VI. There is no preference for plan color by typical users of farm building plans.

Hypothesis VII. There is no preference by typical users of farm building plans for the amount of written explanation about use of the finished building portrayed on a plan.

Hypothesis VIII. There is no preference on size of farm building plansheet by typical plan users.

Hypothesis IX. There is no single preference for the use of farm building plans by typical users of the plans.

III. METHODOLOGY

Sample

A sample of 278 typical plan users were involved in this study. This included 68 operating farmers, 79 staff from the Farmers Home Administration lending agency, 66 county extension agents and 65 secondary and post-secondary agriculture students in North Dakota.

The 278 typical users who participated in the study were considered representative of those that use farm building plans. There were 255 males, 15 females and 8 who did not indicate their sex. The age distribution for the typical user groups is given in Table 1.

TABLE 1

Number, Range and Mean Age for the Four Groups of Typical Farm Building Plan Users.

User Group	Number	Age Range	$\bar{X}$	S
Farmers	68	18-66	35.24	10.21
Lenders	79	22-60	38.33	9.07
Co. Agents	66	24-59	37.77	10.80
Students	65	15-27	18.52	2.11
Totals	278	15-66	32.68	11.86

Although others use plans (i.e., builders, building suppliers, homemakers, engineers, etc.) those sampled in this study are among the majority. Resources were not available for this study to survey other groups.

Farm building plans can be used in various ways by these different persons or users. The county agent or agri-business person is concerned about passing along technology to improve productivity; the farm owner-operator is searching for a functional building that can perform a service and add to his/her assets and prestige; the lending agency is concerned about redeemability, practicality and obsolesence; students in vocational agriculture courses are tomorrow's candidates for these occupations and related positions.

The plan users were purposely accessed through local, on-going, daytime or evening meetings that were organized for other purposes by the local vocational agriculture instructor or the Cooperative Extension Service. Avoiding special questionnaire sessions and/or mailings assisted with obtaining unprepared, naive responses from the users. The desired attitude was to obtain a typical user's immediate reaction after having just received a new building plan. Intuitive and unprepared responses were essential to the study purpose.

Paramount to selection of the on-going group meetings was involving equal numbers of farmers, county

agents, students and lenders. A minimum of 200 respondents was suggested for this type experimental research (Borg and Gall, 1979). The groups representing typical users of farm building plans sampled in the study were selected on the basis of geographical location, availability, interest in use of farm building plans, willingness to cooperate, group size and user characteristics (i.e., age, education, sex, and apparent experience with buildings).

The data were collected from March through June, 1983, throughout North Dakota. A total of 20 separate group gatherings was addressed. The size of these groups varied from 5 to 80 persons. The questionnaire was positively received by each group and seriously considered by those involved. At several of the gatherings, individual comments were made afterward that this questionnaire was innovative and time well spent. Comments included explanations how building plans were generally difficult for them to understand.

Although a statistically randomized selection was not used, the county agents and lenders sampled were from throughout North Dakota. To gain a similar broad input,the farmers, secondary and post-secondary students in the study were especially selected on a scattered location basis. In addition to student location, consideration was given to the use of farm building plans

in the curriculum, size of enrollment in the vocational agriculture program and the local mix of livestock and crop production practices. There was good cooperation with school administrators.

Instruments

Two types of instruments were developed and used for the study. One type consisted of a 28-item questionnaire (Appendix A). The other type was three formats (orthographic, perspective and exploded drawings) of a farm building plan (Appendix B). These two types of instruments were designed to allow typical plan users, first, to determine specifications and document their own responses to understanding a farm building plan and, second, to relate their preferences about selected components. The documented responses provided the data for measuring the typical user understanding and component preferences of the farm building plan.

Questionnaire

In discussion prior to the pilot tests, it was decided that a reasonably brief questionnaire should be employed for the study. About a 15-minute questionnaire completion time was deemed appropriate. The agriculturally-related users that would be involved in the study have an apprehension toward questionnaire studies.

Brief but accurate responses were desired moreso than numerous and perhaps less accurate ones.

Twenty questions with multiple choice response items were developed based on specifications or information provided on the developed plan. The questions were designed so typical plan users would provide similar answers regardless of which of the three plan formats was presented to them.

The questionnaire was devised with some difficult questions and some that were less difficult. Table 2 lists the six most difficult questions to which more than 40 percent of the typical users gave a wrong reply.

TABLE 2

Six Most Difficult Questions in Questionnaire.

Question Number	Correct Reply	Incorrect Reply	Percent Incorrect
3	147	131	47
5	158	120	43
6	144	134	48
12	120	158	57
16	153	125	45
18	116	162	58

Five of the 278 typical users replied correctly to all the questions. There were six questions to which 95 percent or more gave the correct reply as shown in Table 3. This range of difficulty suggested that the questionnaire was not too difficult or simple.

TABLE 3

Six Least Difficult Questions in Questionnaire.

Question Number	Correct Reply	Incorrect Reply	Percent Correct
1	266	12	96
2	270	8	97
8	269	9	97
9	271	7	97
13	267	11	96
19	270	8	97

The overall mean test score for the 278 typical users was 15.12, and the mean test time was 14.40 minutes. A Chronbach's Alpha of 0.60 was obtained for the questionnaire responses in the study. Applied to the Spearman-Brown prophesy formula this indicated the questionnaire needed a total of 223 items to obtain a reliability of 0.90. This number of items would not have been possible to accomplish in this study.

An additional eight questions with multiple choice response items were included in the questionnaire. These sought information on users and their preferences about farm building plans in general rather than information directly from the portrayed plan. Responses to these eight questions provided data about preferences on plan color, sheet size, need for additional explanation on the plansheet about use of the finished building and uses made of building plans by the typical users.

The questions and response items were printed on yellow paper for better identification and ease of recognition by users. Each questionnaire was discreetly identified with the particular plan format that accompanied it when completed by the user. This identification permitted correct categorizing of the data if the plan and the questionnaire became separated after their completion. The typical users were not identified other than by age, occupation and sex.

Plan Format

The treatments were three plan format portrayals of the same pole-frame utility farm building drawn at about the same scale. This type of building is commonly used to shelter livestock, machinery or agricultural materials. Typical plan users would readily recognize this building type but would need to study the building plan to understand particular construction details.

Trained and experienced draftspersons prepared the plans according to common practice, except for the needed variations demanded by the study. Conventional drafting practices were followed on the three plans (e.g., horizontal and vertical configurations and dimensions, material list, title block, etc.) but selected drafting practices were used with each format. One format utilized the orthographic projection technique, another a one-point

perspective, and the third an exploded perspective view technique.

Similarly, supplementary but enlarged details were included on the three plan formats. These details had reference to the same features or parts of the building portrayed on each plan. The details illustrated on a respective plan format were generally consistent with that plan format but to a limited extent, varied in size, clarity and portrayal as did the style used for the printed words. On the orthographic projection format the selected details were relatively small and least clear. Hand lettering, 1/16-inch high, was employed. On the perspective drawing format the selected details were shown larger, with more clarity, and printed, 3/32-inch high capital lettering was used. The selected detail sizes were shown the smallest but relatively clear on the exploded drawing format which also employed larger upper and lower-case lettering. The materials list and written explanation about use of the completed building were located differently on each plan format. These variations provided a source to measure a relationship of details and understanding of building plans.

Each plan format similarly employed line drawings on each side (page) of a standard 11 x 17-inch sheet of white, 60 lb. paper. Although smaller and larger sizes are used in actual practice, this sheet size is among the

common sizes used for farm building plans (Midwest Plan Service, 1957). The first page on each sheet was printed using black ink. The second page was printed using medium navy blue ink. These alternatives provided the basis for different plan user responses to preferences for plan sheet size, color of lines and symbols used with portrayal of farm building plans.

Generally, each plan format was complete and useable in itself. A plan user could be expected to construct the building portrayed. The portrayal differences were noticeably different, however, when the three plan formats were laid beside each other (Appendix B).

Pilot Tests

To initially evaluate a realistic, practical and meaningful approach for conducting the study, a pilot test was planned that used a plan for a small, moveable, calf shelter farm building. The basic approach, questionnaire make-up and calf shelter building plan selection were reviewed individually, and finally as a group, with professors of Agricultural Education and Agricultural Engineering, an experienced draftsperson and a research sociologist. Three different plan formats of this building were drawn. These formats respectively used orthographic, perspective and exploded views.

The subjects involved in conducting this pilot test were 24 students enrolled in an introductory agricultural mechanics course at North Dakota State University. The time used by the subjects (in a classroom setting) to complete the questionnaire about this plan was recorded. The subjects were not told of the use to be made of the questionnaire. Rather they were instructed that it was simply a 'quiz' on their knowledge about farm building plans. Although their knowledge probably was limited about farm building construction, this calf shelter building should have been generally familiar to the group. The students responded with more than 80 percent accuracy. An item analysis of the 24 responses indicated the type of questions selected were appropriate to assist with determining what was understood about the plan.

The more complex pole-frame utility building plan was then eventually selected for the final detailed study. It was considered representative of typical, modern farm building construction. The questionnaire was developed for this pole-frame utility building plan using the pilot test questionnaire as a guide and also the ASAE Plan Judging Form (American Society of Agricultual Engineers, 1982). The final questionnaire and plan format instruments were reviewed with a professor of Agricultural Engineering and the research sociologist. The planned procedures for the distribution of instuments were confirmed by a research statistician.

In a final pilot test, the 28-item questionnaire along with the three different plan formats (respectively employing orthographic projection, perspective and exploded views) was used with a group of 22 county extension agents who were meeting together for another purpose. As there seems increasing apprehension toward questionnaires in agricultural areas, it was considered important that a group meeting for another purpose would provide a "setting" with no premeditated responses. A brief verbal introduction was given first about the growing concern and need to improve understanding of farm building plans. It was explained that the group was being asked to complete this questionnaire to assist agricultural engineers in attacking this need. The county agent group was then briefly urged to (1) carefully study the plan before starting to complete the questionnaire, (2) to record the time used to complete the questionnaire, (3) to work as accurately and quickly as possible and (4) to do individual work. In order to obtain as honest responses as possible, users were discouraged from responding to a question rather than guess. The questionnaire, with one of the three plan formats, was then randomly distributed to each person in the group. Care was exercised so the three plan formats were randomly distributed in a sequenced order. This permitted equal distribution of each plan format with that group. The

completed questionnaire and plans were individually collected as each was completed. The entire questionnaire procedure moved along in an orderly process and lasted about 30 minutes. The group then went on to complete its originial assembled purpose and other than informal, individual visits, no further explanation was made.

The questionnaire results obtained from this procedure were realistic and the procedure was efficient. It was decided to continue the study on this basis.

Procedure

The questionnaire and one of the accompanying, three plan formats were individually handed to each of the 278 typical plan users at the 20 different group, classroom, or meeting settings involved in the study. A brief, verbal explanation of the purpose for the study and what was expected preceded the distribution of the instruments. This explanation was done casually but firmly so that each group realized this was a separate activity. Each user then proceeded at his/her own pace to complete the questionnaire. General observation and supervision were provided as the questionnaires were completed. Rarely, however, were questions asked or were other interuptions experienced. This low-key procedure permitted an unstructured but uniform approach to the varied groups of typical users of farm building plans.

Usually the entire questionnaire session lasted about 30 minutes. The general supervision permitted observation of selected user behavior and the timeframe used to complete the questionnaire. Such direct contact and collection of the responses avoided the complications of a mail survey or other data collection technique. Doubts were also removed as to the sincerity of any users toward completing the questionnaire.

Although each group setting varied in size and location, each without exception cooperated fully. In each of the 20 locations the participants worked quietly and intently at completing the questionnaire. The questionnaire was given at different times of the day varying from around 7:00 a.m. to 9:00 p.m. depending on the particular meeting situation. This seemed to have no effect on user interest, cooperation, or response which appeared to be genuine with very little expressed sarcasm.

Analysis

The data from the 278 completed questionnaires were transposed to Optical Mark Reader sheets. This permitted entering, compiling and analyzing the data through the Statistical Analysis System (SAS) program package and the IBM 4341 computer at North Dakota State University.

Analysis of all 278 user responses was made to address the two major research questions and their related

nine hypotheses. Items correctly responded to for Questions 1-19 and 21 were deemed as "right"; those incorrectly responded to or left blank were said to be "wrong." As expected, every question had not been replied to by each typical user. Again, before completing their questionnaire, plan users had been encouraged not to respond rather than guess at a reply.

The responses to Questions 20 and 22 to 28 were each individually examined for determining the user preferences for amount of written explanation on the plan about use of the finished building, color of lines on the plansheet, size of plansheet, carpenter experience or training on planning buildings and uses made of farm building plans.

Statistical analyses procedures selectively employed from the SAS package included: analysis of variance, Pearson product-moment correlation, Chi-square and item analysis. A 95 percent probability or confidence level was selected. The Duncan's multiple range test was used to test for significant differences among means.

IV. FINDINGS AND DISCUSSION

Nine hypotheses were derived from the related literature to address the two major research questions of this study. The two major questions asked were about the relationship of plan format to understanding and the preferences for selected components of farm building plans by typical users. The presentation of the findings and the related discussions are organized here under abbreviated headings for the two major questions and respective hypotheses.

Understanding of Farm Building Plans

Plan Format and Understanding

The scores of the 278 typical users were the measure of plan understanding. Table 4 summarizes the test scores of the four groups of typical plan users (i.e., farmers, lenders, county agents and students) for the three plan formats in the study (i.e., orthographic, perspective and exploded drawings). Plan users of the two pictorial drawing formats (perspective and exploded) scored significantly higher ($F=7.35$; $df=2, 266$; $p=0.00$) than those who used the orthographic projection format. Orthographic projection is commonly used in the preparation of farm building plans. The pictorial format

TABLE 4. Two-Way Analysis of Variance of Mean Test Score by Plan Format and Typical Plan Users.

Typical Plan Users	Mean Test Score											
	Orthographic			Perspective			Exploded			Totals		
	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
Farmers	22	14.55	2.74	24	15.54	2.15	22	15.45	2.89	68	15.19	2.60
Lenders	25	14.96	2.13	28	16.96	2.27	26	15.58	1.88	79	15.87	2.24
Co. Agents	21	15.10	2.19	22	16.55	1.26	23	15.83	2.25	66	15.83	2.01
Students	22	13.00	2.78	21	13.86	2.61	22	13.95	2.79	65	13.60	2.72
Totals	90	14.40	2.57	95	15.82	2.41	93	15.23	2.52	278	15.12	2.33

Source of Variance	SS	df	MS	F	P
Format (A)	81.68	2	40.84	7.35	0.00
Users (B)	222.00	3	74.00	13.33	0.00
A x B	18.44	6	3.07	0.55	0.77
Residual	1477.23	266	5.55		
Totals	1799.35	277	123.46		

(i.e., perspective and exploded drawings) was promulgated in the literature to be more understandable. Its successful use, however, was not substantiated in the literature. This study finding is supportive that pictorial drawings truly are easier to understand and should be used with farm building plans.

Typical User Understanding

The Duncan's test ($p=0.05$; $df=266$; $MSE=5.55$) further indicated a significant difference between the test scores of students and the other three typical user groups of farm building plans included in the study. From a total possible test score of 20 points, farmers, lenders and county agents scored an average of 15.63 correct while students averaged 13.60. Each user group involved what were considered typical users of farm building plans. Each group should have had a similar understanding of what was portrayed on the plan. The lower student test scores could be attributed to their generally narrower range of experience which should include planning buildings and doing actual construction. A comparable relationship of age to understanding was identified in an earlier picture interpretation study (Kennedy, 1974). It is understandable that older persons would have had more opportunities to have reckoned with reasoning type situations including interpreting farm building plans,

working with carpenters, applying construction techniques and building materials. Thus the use of drawings, their unique terminology, dimensions, etc., would not be as strange to them. The questionnaire wording probably most affected student understanding because of their limited general familiarity with farm buildings. This familiarity is a part of experience. More study is needed on these factors.

The significantly lower student test scores emphasized the extensive understanding that must be included when preparing building plans. Other aspects about user building training and experience are discussed later.

Interaction to Understanding by Plan Format and User

No interaction effect ($F=0.55$; $df=6, 266$; $p=0.77$) was determined between the plan format used and the scores of the typical plan users. In other words, the significantly different test scores due to plan format or due to the typical user group were not interrelated. This lack of interaction was supportive that understanding farm building plans depended on plan format or on the typical user.

Time Needed for Understanding

As shown in Table 5 the amount of time needed by the typical users to complete the questionnaire ranged from an average of 16.77 minutes for the 22 students using the orthographic plan format to 12.60 minutes for the 20 county agents using the same format. The average time for all 278 users was 14.40 minutes. These achieved times were realistic considering the relative difficulty of the questionnaire and the plan instruments. The times were in line with the approximate 15 minutes expected to complete the test. Regardless of format, county agents and lenders used less time. This reflects on their routine association with doing "paperwork."

Pearson product-moment correlation coefficients were computed between test scores and test times to explore their validity. A slight negative total correlation coefficient was found of -0.17 (N=272, p=0.00) as shown in Table 6. As can be noted, correlation coefficients ranged from -0.55 for students using the orthographic format to 0.32 for lenders using the perspective format. More of the coefficients were negative. The negative correlations suggest that the users may have hurried to complete the test. The peer pressure of working in a group setting (as was used in this study) could have contributed to this. This element was not observed, however, during data collection. Usually there

TABLE 5. Two-Way Analysis of Variance of Mean Test Time by Plan Format and Typical Plan Users.

Typical Plan Users	Mean Test Time											
	Orthographic			Perspective			Exploded			Totals		
	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
Farmers	22	15.32	3.78	24	14.50	4.02	22	15.18	3.84	68	15.00	3.88
Lenders	25	14.40	3.61	27	13.70	2.84	24	13.71	2.35	76	13.94	2.93
Co. Agents	20	12.60	3.19	22	13.18	3.83	21	13.86	3.40	63	13.21	3.47
Students	22	16.77	3.96	21	14.67	3.47	22	14.95	4.02	65	15.46	3.82
Totals	89	14.81	3.88	94	14.00	3.53	89	14.42	3.44	272	14.40	3.53

Source of Variance	SS	df	MS	F	P
Format (A)	26.29	2	13.15	1.04	0.35
Users (B)	202.94	3	67.65	5.38	0.00
A x B	62.57	6	10.43	0.83	0.55
Residual	3270.76	260	12.58		
Totals	3562.56	271	103.81		

TABLE 6. Pearson Product-Moment Correlation Coefficients between Test Score and Test Time by Plan Format and Typical Plan Users.

Typical Plan Users	Correlation Coefficient between Test Score and Time											
	Orthographic			Perspective			Exploded			Totals		
	r	N	p	r	N	p	r	N	p	r	N	p
Farmers	-.14	22	.53	-.28	24	.18	.28	22	.20	-.04	68	.73
Lenders	.11	25	.60	.32	27	.10	-.23	24	.28	.07	76	.53
Co. Agents	.10	20	.67	-.27	22	.23	.03	21	.90	.01	63	.96
Students	-.55	22	.01	-.15	21	.49	-.32	22	.15	-.38	65	.00
Totals	-.25	89	.02	-.14	94	.18	-.07	89	.50	-.17	272	.00

were one to three users who worked several minutes longer than the others at each location. To a point, the use of more time to complete the test could have resulted in more accuracy. Since there was a maximum test score achieveable, however, an excessive time used would again eventually show a negative correlation because test users would need more time than normal to get a perfect score. It seems logical that slower thinkers would use more time.

To expedite the group test process and also to not chance influencing results by using timers, typical users were asked to record their own starting and ending times. This procedure could have aided a negative correlation as it was observed a few users tended to be lenient when recording their time.

Considering these aspects it appeared that overall a legitimate relationship existed between the study test scores and times.

Any of the three formats would yield the same maximum test score. The easier plan format to understand should have taken less time. A significant negative correlation coefficient of -0.25 (N=89, p=0.02) was indicated for the orthographic format. This suggests that it probably was the more difficult format to understand. Neither pictorial format had a significant coefficient which suggests their test scores were unaffected by test times or that test times were unaffected by test scores for these formats.

To look further at effect of plan format on time needed to understand a plan, a two-way analysis of variance was computed using time as the dependent variable with typical users and plan format as independent variables. This analysis (Table 5) shows that although the orthographic format required the most time to complete the test, differences among groups were not statistically significant ($F=1.04$; $df=2, 260$; $p=0.35$).

The Duncan's test of users mean times suggested that students and farmers needed significantly ($p=0.05$; $df=260$; $MSE=12.58$) more time to complete the test than county agents and lenders. This finding is understandable when again one considers the lower probable planning experiences of these typical user groups. Lenders and county agents would have had more opportunity to work with planning, plans, drawings, strange terminology, etc. Younger students would probably not have been exposed to as much general planning or to as much building planning and construction as would older persons.

No interactive effects ($F=0.83$; $df=6, 260$; $p=0.55$) were found between plan format and typical users mean test times. This suggests that variations in time needed to understand plans depended on either the format used or the typical user.

User Experience and Plan Understanding

A questionable dimension existed between the relationship of mean test time and mean test score to the training and experience levels of the typical users sampled in the study. One might logically expect that more training on planning buildings or more carpenter experience would result in a higher test score in less time. Questionnaire Question 24 (Appendix A) queried this dimension. A one-way analysis of variance of test time by typical user groups was conducted. Table 7 shows that although a smaller group, the users who indicated several years training or experience (Item 4) had the lowest mean test time of 14.00 minutes. This was not significantly (Duncan's multiple range test, p=0.05; df=265; MSE=13.19) different, however, than the mean test time (14.75 minutes) for the group in Item 1 that indicated about 1 year experience. The different group mean test time findings suggests that building training or carpenter experience is unecessary for understanding a building plan.

That the times were not significantly different could probably be attributed to user interpretation of Question 24. Intended to relate to both the hands-on and classroom type building experiences, the terms "carpentered" and "training on planning farm buildings" could have been interpreted differently.

TABLE 7. One-Way Analysis of Variance of Plan User Group Mean Test Time and Training.

Training	User Group Mean Test Time (Minutes)														
	Farmers			Lenders			Co. Agents			Students			Totals		
	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
--	1	12.00	-	1	20.00	-	1	10.00	-	-	-	-	3	14.00	5.29
None	47	14.98	3.55	32	13.75	3.05	44	13.25	3.32	37	15.95	3.42	160	14.48	3.49
1 mo.	10	15.10	4.56	13	13.69	3.17	5	15.80	3.27	15	13.87	2.85	43	14.32	3.41
1 yr.	4	16.50	6.14	9	14.78	2.59	4	13.25	3.40	7	14.57	5.03	24	14.75	4.04
Sev. yrs.	6	14.33	4.27	21	13.71	2.72	9	12.00	4.15	6	17.67	6.31	42	14.00	4.12
Totals	68	14.96	3.85	76	13.93	2.96	63	13.22	3.47	65	15.48	3.89	272	14.40	3.63

Source of Variance	SS	df	MS	F	P
Training	10.95	3	3.65	0.28	0.84
Within Groups	3495.89	265	13.19		
Totals	3506.83	268	16.84		

Another one-way analysis of variance was used to examine the relationship of test scores with indicated plan user training on planning buildings and carpenter experience (Table 8). The observed mean test scores increased directly with indicated user training and experience. The differences in mean test scores, however, were not significant ($F=0.85$; $df=3, 271$; $p=0.47$).

Most (75 percent) of the typical users sampled indicated one month or less training or experience. However, their mean test times and scores were not significantly different than those users who indicated more training or experience. This suggests that the plan was understandable although most users were typically inexperienced with planning buildings or carpentering. Although other users who more frequently use building plans (i.e., builders, engineers, vocational agriculture teachers, etc.) might affect this finding, training on planning buildings and carpenter experience apparently are not needed or particularly helpful for understanding building plans.

These findings about the time needed to understand a farm building plan support the findings for the first research question about the effect of format on plan understanding. Although differences were indicated, a farm building plan should be as understandable in about the same length of time regardless of who is the user.

TABLE 8. One-Way Analysis of Variance of Plan User Mean Test Score and Training.

Training	User Group Mean Test Score														
	Farmers			Lenders			Co. Agents			Students			Totals		
	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
--	1	19.00	-	1	16.00	-	1	16.00	-	-	-	-	3	17.00	1.73
None	47	15.15	2.52	34	15.18	2.34	47	15.70	2.08	37	13.59	2.65	165	14.96	2.50
1 mo.	10	14.90	3.48	13	17.23	1.64	5	15.60	1.52	15	13.20	2.91	43	15.21	3.06
1 yr.	4	14.75	0.96	9	16.11	1.83	4	17.00	1.15	7	14.43	1.40	24	15.54	1.72
Sev. yrs.	6	15.67	2.50	22	16.05	2.30	9	15.56	2.24	6	13.67	4.08	43	15.56	2.64
Totals	68	15.19	2.60	79	15.87	2.24	66	15.83	2.01	65	13.60	2.72	278	15.17	2.56

Source of Variance	SS	df	MS	F	P
Training	16.72	3	5.57	0.85	0.47
Within Groups	1777.46	271	6.56		
Totals	1794.18	274	12.13		

The results of analyses about user test scores and user test times versus training on planning buildings and carpenter experience generally support the study validity and reliability. In this study the development of instruments and procedures were relatively arbitrary since no related standards for evaluating building plan understanding were discussed in the literature. The support by the resulting test times and test scores had special meaning considering the desired brevity used with as broad approach possible in the study. Again it should be emphasized that honest, naive responses from typical users of farm building plans were a high priority in this study. In agricultural areas a general resentment exists toward questionnaires and it was feared a lengthy questionnaire would have detracted from the accuracy of overall study results.

Enlarged Details and Plan Understanding

An essential part of a plan format is the enlarged details which portray key parts of the building construction. The relative size and clarity of details could affect understanding of the overall plan. As previously discussed, details were drawn somewhat different on the three plan formats (Appendix B). The details were portrayed slightly larger and with better clarity on the perspective format, for example, as compared to the other two formats.

The responses to three selected questions in the questionnaire (Appendix A) were studied to verify the understanding of key parts of the building walls and how this related to general understanding of the building plan. The question number and statements were:

Number	Question
6	The rafters are fastened at the poles with:
8	The pole depth into the ground is:
16	The minimum height off the groundline for the siding is:

Pearson product-moment correlation coefficients were computed between user responses to the three questions and their adjusted total test scores. Table 9 shows the total, positive correlation coefficients that were found for each plan format. This finding tends to support the contention that detail understanding was related to plan understanding. The higher correlation coefficients for the perspective and exploded formats suggested these formats complemented the mutual understanding of the complete building plan and the general construction detail portrayed.

A two-way analysis of variance was used to further study the relationship of detail size and clarity to plan understanding. Table 10 shows that the user mean score for Questions 6, 8 and 16 for the perspective format (2.26) was significantly ($F=6.51$; $df=2, 266$; $p=0.00$)

TABLE 9. Pearson Product-Moment Correlation Coefficients Between Correct Responses to Questions 6, 8 and 16 and Total Test Score (excluding Questions 6, 8 and 16).

Typical Plan Users	Correlation Coefficient											
	Orthographic			Perspective			Exploded			Totals		
	r	N	p	r	N	p	r	N	p	r	N	p
Farmers	.32	22	.14	.30	24	.15	.76	22	.00	.47	68	.00
Lenders	.32	25	.12	-.03	28	.86	-.04	26	.85	.15	79	.19
Co. Agents	.20	21	.37	.00	22	1.00	.29	23	.17	.23	66	.06
Students	-.09	22	.69	.29	21	.20	.34	22	.12	.15	65	.22
Totals	.22	90	.04	.30	95	.00	.38	93	.00	.31	278	.00

higher than mean scores for the orthographic and exploded formats (Duncan's multiple range test: p=0.05; df=266; MSE=0.51). This finding suggests that the larger details with better clarity on the perspective plan format affected plan understanding.

Students achieved a significantly (F=6.49; df=3, 266; p=0.00) lower mean score (1.69) than did county agents, lenders or farmers for Questions 6, 8 and 16 (Duncan's multiple range test: p=0.05; df=266; MSE=0.51). As suggested earlier, this may be attributable to the few and narrow range of opportunities by students to do general planning or be involved with building construction. No interaction was found between users and format (F=1.52; df=6, 266; p=0.17).

Questions 11, 12 and 21 were concerned with clarity of enlarged, roof framework details and the plan understanding by typical users. The question number and related statements were:

Number	Question
11	The 2 x 4 roof purlins are installed:
12	The size of the rafter support girders are:
21	The size of lumber used for the intermediate rafter tie is:

Results of a two-way analysis of variance indicated that the scores for the typical user groups to these questions did not differ significantly (F=0.94; df=3, 266; p=0.42).

TABLE 10. Two-Way Analysis of Variance of User Mean Score for Questions 6, 8 and 16 by Plan Format and Typical Plan Users.

Typical Plan Users	Mean Score for Questions 6, 8 and 16											
	Orthographic			Perspective			Exploded			Totals		
	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
Farmers	22	2.05	0.84	24	2.13	0.68	22	2.14	0.77	68	2.10	0.76
Lenders	25	2.04	0.73	28	2.54	0.69	26	1.85	0.61	79	2.15	0.74
Co. Agents	21	2.00	0.77	22	2.55	0.51	23	1.96	0.71	66	2.17	0.71
Students	22	1.68	0.72	21	1.76	0.89	22	1.64	0.58	65	1.69	0.72
Totals	90	1.94	0.77	95	2.26	0.76	93	1.89	0.68	278	2.04	0.75

Source of Variance	SS	df	MS	F	P
Format (A)	6.63	2	3.32	6.51	0.00
Users (B)	9.92	3	3.31	6.49	0.00
A x B	4.66	6	0.78	1.52	0.17
Residual	135.56	266	0.51		
Totals	156.77	277	7.92		

A significantly (Duncan's multiple range test: p=0.05; df=266; MSE=0.52) better understanding of building details was indicated, however, for the perspective and exploded portrayal formats than the orthographic projection format.

Although these findings support the contention that the size and clarity of enlarged detail drawings facilitate plan understanding, there may be another explanation. This is that a synergistic relationship exists between the plan format used and the detail drawings or vice versa. The pictorial drawings better compliment the detailed drawings or are complimented by them, whereas the mutual compliment may be less for the orthographic format.

This relationship to general understanding of a plan between enlarged building details and plan format was too briefly addressed in this study. Further study is needed to make extensive conclusions.

TABLE 11. Two-Way Analysis of Variance of User Mean Score for Questions 11, 12 and 21 by Plan Format and Typical Plan User.

Typical Plan Users	Mean Score for Questions 11, 12 and 21											
	Orthographic			Perspective			Exploded			Totals		
	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
Farmers	22	0.95	0.79	24	1.00	0.78	22	1.18	0.85	68	1.04	0.80
Lenders	25	0.75	0.60	28	1.46	0.64	26	1.08	0.69	79	1.11	0.70
Co. Agents	21	0.86	0.73	22	1.32	0.65	23	1.35	0.65	66	1.18	0.70
Students	22	0.82	0.66	21	1.00	0.77	22	1.09	0.87	65	0.97	0.77
Totals	90	0.84	0.69	95	1.21	0.73	93	1.17	0.76	278	1.07	0.74

Source of Variance	SS	df	MS	F	P
Format (A)	6.92	2	3.46	6.61	0.00
Users (B)	1.48	3	0.49	0.94	0.42
A x B	4.06	6	0.68	1.29	0.26
Residual	139.25	266	0.52		
Totals	151.71	277	5.15		

User Preferences for Selected Plan Components

Four specific components of typical farm building plans were queried in response to the second research question. These components were: (1) amount of written explanation about use of the finished building, (2) plansheet color, (3) plansheet size, and (4) use made of plans. The questionnaire Questions 20, 22, 23 and 25 (Appendix A) respectively asked for user reaction about these components. Questions 1, 2, 7, 13, 14, 19, 24 and 27 provided supplemental information.

Plan Color Preference

The receptiveness and use of a plan was influenced by its color. Response to Question 22 of the questionnaire (Appendix A) supplied data for analysis of user preferences about the portrayed plan component of color. Summarized in Table 12, these data showed that 41 percent of the users preferred blue lines on white paper. Although nearly as many persons (37 percent) had no color preference, the majority supported the common idea that "plans" and "blueprints" are synonomous. A much smaller group (22 percent) preferred black lines.

Generally the same color preferences were indicated among the different types of users. This finding complements other legibility studies that show preferences for the blue and white color combination.

TABLE 12

Number (N) and Percentage (%) of Preferences for Different Color Combinations by Typical Plan Users

	Number of Preferences									
	Farmers		Lenders		Co.Agents		Students		Totals	
Item Number	N	%	N	%	N	%	N	%	N	%
1,blue on white	24	36	32	41	30	45	26	41	112	41
2,black on white	13	19	20	25	13	20	16	25	62	22
3,white on blue	0	0	0	0	1	0	0	0	1	0
4,no preference	30	45	27	34	22	33	22	35	101	37
Total users	67	100	79	100	66	100	64	100	276	100

(One sample: $X^2=109.34$; df=3; $p<0.05$)

To be practical a plan is printed only one way. So for statistical analysis, the totals for the user groups listed in Table 12 were considered as one group. The calculated Chi-square value of 109.34 was significant for the preference of blue lines on white paper.

Written Explanation Preference

Plan users sampled in the study were provided four response choices or items to Question 20. This question related to preference for written explanation about use of the finished building portrayed on the plan. Table 13 shows the results of the Chi-square analysis used to evaluate the total numbers of responses to these items.

The majority of users (62 percent) indicated that no more written explanation about use of the finished

TABLE 13

Number (N) and Percentage (%) of Preferences by Typical Plan Users for Written Explanation on the Plan About Use of the Finished Building

	Number of Preferences									
	Farmers		Lenders		Co.Agents		Students		Totals	
Item No.	N	%	N	%	N	%	N	%	N	%
1,no more	36	55	57	73	36	56	39	61	168	62
2,not sure	11	17	7	9	11	17	9	14	38	14
3,m. notes	3	5	2	3	4	6	5	8	14	5
4,one page	15	23	12	15	13	20	11	17	51	19
Totals	65	100	78	100	64	100	64	100	271	100

(One sample: $X^2=208.03$; df=3; $p<0.05$)

building be included on the plan (Item 1). Each user group supported this majority. A minimum explanation was used with the study plan.

To be practical a plan can only be prepared one way. To make a statistical analysis of the responses, the four groups were collapsed into one group. The computed Chi-square statistic of 208.03 was significant for the 62 percent of users who preferred no more written explanation on the plan about use of the finished building.

Selected questionnaire responses were cross-checked to look further at the reliability of responses, user preference and need for written explanation about use of the finished building included on a plan. The first cross-check involved Questions 20, 24 and 27 which

examined the users' preference and general understanding of construction. The question number and statements were:

Number	Question
20	Is more written explanation needed on this plan about use of the finished building?
24	Have you carpentered or had training on planning farm buildings?
27	Could you use this plan to build a pole barn?

Of the 278 sampled users, 26 percent indicated the following general understanding:

Item 1 for Question 20--no need for more written explanation.

Item 3 or 4 for Question 24--a year or more of training on planning farm buildings

Item 1 for Question 27--yes, could build the pole barn.

The remaining 84 percent of the users either wanted more explanation, had less than one year of training on planning buildings or carpenter experience or were doubtful they could construct the building portrayed on the plan. This cross-check result raised doubts about user understanding of Question 20. The terminology used may have suggested to some users that the question referred to written explanation about the plan rather than the end use of the building portrayed. A larger group in this cross-check would have indicated better general understanding of plans and been supportive to a valid indication of user understanding of Question 20.

A second cross-check was made of Questions 13, 14 and 20 to further examine if users needed more written explanation about the finished building's use. The question numbers and statements were:

Number	Question
13	The pole-frame utility barn is used for:
14	On what page did you find the information to answer Question 13?
20	Is more written explanation needed on this plan about use of the finished building?

Of the 278 users, 58 percent correctly replied to Question 13, 14 and also indicated no preference for more written explanation (Question 20). A majority of the users thus apparently understood the written explanation that was provided about the end use of the portrayed building. This cross-check reduced some of the concern about the understanding of Question 20.

A final cross-check about need for more written explanation on use of the finished building shown on a plan was made to determine if users had observed and understood fundamental information supplied on the portrayed plan. Questions 1, 2, 7 and 19 each sought basic, portrayed information that should have been obvious to the plan user. The question number and statements were:

Number	Question
1	The length of the building shown is?

2 The building width is?

7 How many pages are there for this plan?

19 When was this plan drawn?

A large majority (85 percent) of the 278 users sampled correctly responded to these four basic questions. This size of majority again supported the general understanding of the plan and the written explanation about use of the finished building included on the plan portrayed. This finding further reduced doubt about misinterpretation of Question 20.

Plansheet Size Preference

The plansheet used in the study was a typical 11 x 17-inch size. Question 23 of the questionnaire (Appendix A) addressed the 278 typical users about their preferences for smaller or larger plansheet sizes. Table 14 shows the distribution of the three item responses or choices available for Question 23.

None of the users indicated that a farm building plan should be smaller (Item 1), although an 8.5 x 11-inch size is sometimes used. The majority of the 274 typical users who responded to this question preferred the 11 x 17-inch plansheet size. The four groups of typical plan users were consistent in their preferences as shown by the numbers in Table 14. That this was the size used in the study probably influenced this result.

TABLE 14

Number (N) and Percentage (%) of Preferences for Plansheet Size by Typical Plan Users

Item Number	Number of Preferences: Farmers N	Farmers %	Lenders N	Lenders %	Co.Agents N	Co.Agents %	Students N	Students %	Totals N	Totals %
1,smaller	-	-	-	-	-	-	-	-	-	0
2,ab't right	59	89	71	91	63	95	53	83	246	90
3,2x larger	7	11	7	9	3	5	11	17	28	10
Totals	66	100	78	100	66	100	64	100	274	100

(One sample: X^2=173.44; df=1; p<0.05)

To be practical only one plansheet size is usually printed for all users. For statistical analysis all users were grouped together. The computed Chi-square value of 173.44 was significant for the 90 percent who indicated the 11 x 17-inch plansheet was about the right size.

The responses appeared reasonably valid. The typical users sampled should have been generally familiar with available plansheet sizes and able to contemplate their major differences (i.e., awkwardness of large sheets, difficulty to read smaller words, need for more sheets, etc.). The indicated preference for the 11 x 17-inch size can be useful. Further study on this preference is suggested, however. One study might be to look closer at the preferences for the same plan that is actually portrayed on different plansheet sizes (i.e., 8.5

x 11, 11 x 17, 18 x 24-inches, etc.). Such an in-depth comparison could more actually appraise user preference.

Plan Use Preference

In questionnaire Question 25 the users were given these four choices as to the purpose for which they usually used farm building plans:

(1) actual construction of the building shown?

(2) advising cooperators and/or customers on their building needs?

(3) source of design information for other construction?

(4) selling or purchasing building materials?

Of the 278 typical plan users sampled in the study, 261 responded to this question. Table 15 shows the use preferences by the four typical user groups. The most frequent response (41 percent) was to advise about building needs.

It is relevant here to note that although a majority (80 percent) of the users indicated in response to Question 27 they could construct the building, about two-thirds would use the plan for other purposes.

The type of user is usually not known when a plan is prepared. To be practical only one format of a plan can be prepared. The chosen format has to suit all typical plan users for their different uses. A more suitable format should encourage more plan use. For these

TABLE 15

Number (N) and Percentage (%) of Indicated Uses for Farm Building Plans by Typical Plan Users

	Number of Indicated Uses									
	Farmers		Lenders		Co.Agents		Students		Totals	
Item Number	N	%	N	%	N	%	N	%	N	%
1,actual cons.	31	48	12	16	4	6	35	61	82	31
2,advising	4	6	55	71	44	70	5	9	108	41
3,design	24	38	9	12	13	21	10	18	56	22
4,sales	5	8	1	1	2	3	7	12	15	6
Totals	64	100	77	100	63	100	57	100	261	100

(One sample: $X^2=123.44$; df=9; $p<0.05$)

reasons the typical user groups in Table 15 were grouped together for statistical analysis of the responses to each item. The 41 percent who indicated a preference for using plans for advising was significant, followed by the 31 percent who used plans for actual construction ($X^2=123.44$; df=9; p[0.05). Although a useful finding, other groups of typical users (i.e., builders, engineers, etc.) could influence this finding.

The use made of farm building plans should have an effect on their format. Plans that are used for "planning" moreso than actual construction would need to emphasize building layout, functional and appearance features. Although not eliminated, less attention would need to be devoted to location of nails, door framework, window installation, complete material specifications,

roof bracing diagrams, and other involved details that are useful for specific construction. From the suggested broad usage need for farm building plans, a generally broad and inclusive format with minimum involved detail seems adviseable. This agrees with the study by Gustafson (1967).

V. SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to determine the effect of format on the understanding and preferences for selected components by typical users of farm building plans. Format refers to the size, shape and general makeup of something drawn. A farm building plan is a drawing that portrays information about the layout, materials use, construction and appearance of a structure used for machinery, livestock or other agricultural production purposes.

In addition to farmers, a variety of people use farm building plans for different purposes. Many are infrequent users and unfamiliar with plans and planning. Understanding plans is essential to their practical application. Little study has been done about user understanding and actual use made of building plans. Studies have been done about understanding pictures, drawings, colors, signs, illustrated written materials and drafting. Some of these findings (e.g., newspaper style layout, lettering styles, use of color, illustration and detail size) were incorporated in the study plan.

Three, basic, portrayed formats (i.e., orthographic, perspective and exploded drawings) were used in the study to portray the same pole-frame farm building plan. Twenty questions in a questionnaire were asked about construction of the portrayed building. Eight additional questions were asked about the users and their preferences. These included amount of written explanation on the plan about use of the finished building, plansheet color, plansheet size and use made of plans. The study was designed to be brief, yet as inclusive and accurate as possible.

The questionnaire with one of the three plan formats was administered to 278 typical plan users at 20 different group sessions (held for other purposes) around North Dakota in early 1983. This sampling involved 68 farmers, 79 lenders, 66 county agents and 65 agriculture students. The ages of typical users in the study ranged from 15 to 66 years. The average age was 32.7 years.

The first four study hypotheses addressed the relationship between plan format and typical user understanding of the plan. Questionnaire response analysis indicated that typical users had a significantly lower mean test score with the orthographic projection format (14.40) than for the perspective (15.82) or exploded (15.23) formats. Student users had a significantly lower plan understanding than did farmers,

lenders or county agents. No interactions were found between the formats and users.

The time used to understand the plan and complete the questionnaire was not significantly affected by plan format. The mean test time for the 278 users sampled was 14.40 minutes. The mean test times for students (15.46 minutes) and farmers (15.00 minutes) were significantly higher than for lenders (13.94 minutes) or county agents (13.21 minutes). Further analysis determined the indicated user training on building planning or carpenter experience had no significant relationship to plan understanding or time needed to complete the questionnaire.

A fifth hypothesis addressed the relationship of enlarged details and plan understanding. Detail understanding was significantly better for the perspective and exploded plan formats and these formats aided understanding of plans.

The four final hypotheses dealt with plan user preferences. Typical plan users significantly preferred plans printed with blue lines on white paper. Users also preferred a minimum of explanation on the plan about use of the portrayed building. A significant preference was indicated for the 11 x 17-inch size plansheets and typical users used plans first for planning and secondly for construction.

Conclusions

A typical farm building plan is more understandable, regardless of user type, when portrayed using a pictorial format than if portrayed by orthographic projection. Plan understanding is more difficult for younger age users and for users who do not generally do planning. Understanding a plan is related to portrayal quality of the enlarged building details. A pictorial format aids understanding the details. Building plans with blue lines on white paper are preferred by plan users.

There is evidence to support user preference for 11 x 17-inch size plansheets. Other evidence supports including on a plan only the minimum amount of written explanation about use of the completed building.

Although doing planning is a major use made of farm building plans, plans are also used for doing actual construction.

Implications and Recommendations

The pictorial plan format should be readily employed by those who prepare farm building plans as should the use of blue lines on white 11 x 17-inch paper. A minimum of written explanation on the plan about use of the completed building portrayed should be utilized whenever possible for more efficient and enhanced use of plans.

Although this study helped, there is need for further study to provide for greater improvements in understanding and use of farm building plans. It is imperative that more be done on the following items to clarify the findings of this study and to further determine format improvements for more extensive and efficient use of farm building plans:

1. This study should be replicated with the same groups as well as with teachers, homemakers, builders, building suppliers, engineers and other user groups (that can be identified) from larger geographical areas. Some means of determining better ways for explaining building terminology could be incorporated with this study or be a separate study in itself.
2. Development of techniques to portray complete building plans using exploded type technical illustration should be pursued. This technique could simplify and improve understanding of even complex buildings. Computer-aided design might be adapted to more readily accomplish this.
3. The student group in this study indicated the poorer understanding of plans. Their input should therefore be sought and utilized for making plans more understandable. One scheme would be to employ a regional pre- and posttest or questionnaire

(similar to the one used in this study) about one or more selected plans. This could be a regular part of secondary and post-secondary courses on farm building construction. As an integral part of this effort, organized, regular feedback of findings should be provided to on-going preparers of plans (e.g., MWPS, WRAES, CFBPES, etc.) who in turn can incorporate suggestions on plans as they are developed. Building design changes will continue to evolve (e.g., solar collector use) and regular feedback would aid in effective diffusion of such new developments.

4. A follow-through study of a popular plan that is used for actual construction on a multi-state basis would provide valuable plan understanding information. A uniform checklist would need to be developed so different evaluators involved in the different states can uniformly note key items. As a part of this, a more detailed examination should be addressed about the relationship of plan understanding to training on planning buildings and to carpenter experience.
5. An in-depth study is needed about the ratio or optimum size relationship of building details to the main views of the portrayed building. Generally a 1.5 to 2 larger size ratio for enlarged

details seems feasible. A consistent, uniform relationship would be less confusing to infrequent farm building plan users and optimize page space use.

6. Additional study about the best size of plansheet to use is also needed. This could employ the same plan and format on different sized sheets. Included with this should be a measure of the maximum and minimum amount of written explanation to use with a plan.

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APPENDICES

APPENDIX A

Building Plan Questionnaire

Appendix A

March 1983

Dexter W. Johnson
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BUILDING PLAN QUESTIONNAIRE

Directions: We are interested in improving the understanding of our farm building plans. If you use farm building plans, your answers to the following questions will help guide us in doing this. Please --

a. Study over the building plan given you.
b. Mark the most correct answer, some choices are not exact.
c. Do your best but work as fast as possible too.
d. Recheck answers and then return all materials together.

Thank you! Starting Time _____ Ending Time _____

1. The length of the building shown is:

( ) 16 feet
( ) 28 feet
( ) 42 feet
( ) 64 feet

2. The building width is:

( ) 28 feet
( ) 32 feet
( ) 42 feet
( ) 64 feet

3. The height of the open front is:

( ) 8 feet
( ) 11 feet
( ) 14 feet
( ) 16 feet

4. The number of round poles needed for the building shown on page 1 is:

( ) 24
( ) 28
( ) 32
( ) 36

5. The rafter spacing for the all-pole type construction is:

( ) 2 feet
( ) 4 feet
( ) 8 feet
( ) 16 feet

6. The rafters are fastened at the poles with:

( ) ring shank nails
( ) bolt
( ) nails and bolt
( ) two bolts

7. How many pages are there for this plan? _____

8. The pole depth into the ground is:

( ) 3 feet
( ) 4 feet
( ) 5 feet
( ) 6 feet

9. The slope of the roof is:

( ) 1:12
( ) 2:12
( ) 3:12
( ) 4:12

10. The pole sizes along the open front are:

( ) 4.5 inches diameter x 16 feet
( ) 5 inches diameter x 16 feet
( ) 5.5 inches diameter x 16 feet
( ) 5.5 inches diameter x 14 feet

11. The 2 x 4 roof purlins are installed:

( ) flat over the rafters
( ) on edge over the rafters
( ) on edge between the rafters
( ) either flat or on edge

12. The size of the rafter support girders are:

( ) 2 x 6 inch
( ) 2 x 10 inch
( ) 2 x 10 inch and 2 x 12 inch
( ) 2 x 6 inch, 2 x 10 inch and 2 x 12 inch

13. The pole-frame utility barn is used for:

( ) livestock housing
( ) crop storage
( ) machinery storage
( ) all of these

14. On what page did you find the information to answer question 13? _____

15. The pole-to-rafter braces are:

( ) 2 x 4 inch
( ) 2 x 6 inch
( ) 2 x 8 inch
( ) 2 x 10 inch

16. The minimum height off the groundline for the siding is:

( ) 1 feet
( ) 2 feet
( ) 3 feet
( ) 4 feet

17. The rafter spacing for the part clearspan type construction is:

( ) 2 feet
( ) 4 feet
( ) 8 feet
( ) 16 feet

18. How many different widths of buildings can be built from the plan?

( ) 2
( ) 3
( ) 4
( ) 5

19. When was this plan drawn? _____

20. Is more written explanation needed on this plan about use of the finished building?

( ) no
( ) not sure
( ) use more scattered notes on the plansheets
( ) include a page of written directions with the plan

21. The size of lumber used for the intermediate rafter tie is:

( ) 2 x 4 inch
( ) 2 x 6 inch
( ) 2 x 8 inch
( ) 2 x 10 inch

22. A building plan is easier for you to understand with:

( ) blue lines on white paper
( ) black lines on white paper
( ) white lines on blue paper
( ) line and paper colors do not matter

23. The sheet size of this plan:

( ) could be smaller
( ) is about right
( ) would be easier to understand if twice as large

24. Have you carpentered or had training on planning farm buildings?

( ) no
( ) at least a month
( ) about a year
( ) several years

25. For what purpose do you usually use farm building plans?

( ) actual construction of the building shown
( ) advising cooperators and/or customers on their building needs
( ) source of design information for other construction
( ) selling or purchasing building materials

26. Please indicate your age_____, occupation _____ and sex _____.

27. Could you use this plan to build a pole barn?

( ) yes
( ) no
( ) not sure

→28. If no or not sure, please explain why.

_____

_____

Ending Time _____ Thank You!!

APPENDIX B

Building Plans in Three Formats