Avoiding Graphic Illiteracy: Incorporating Architectural Graphics into the Engineering Curriculum

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Abstract

Major problems stem from graphic illiteracy resulting in interdisciplinary communication breakdown in the engineering field. Factors that distinguish the exceptional engineer include the ability to make, read, and interpret plans; effective interdisciplinary communication skills; and the ability to combine creative thinking and visualization to make unique designs. Incorporating architectural graphics into the general engineering curriculum exposes all engineering students across the disciplines to a universal language and the creative design process. The practical application of architectural graphics is presented across the fields of general, civil, mechanical, and electrical engineering.

Introduction

Engineering graphics is a fundamental communication medium used by technically trained people worldwide to design, construct and operate structures, machines or products. The registered professional engineer (P.E.) assumes a working and legal responsibility for the technical correctness of a device or design as represented by the engineering graphic language. The design effort is hampered by the inability of an engineer to read the interfacing plans of the engineering disciplines. This graphic illiteracy creates a schism not only between applied and research engineers but also between engineers of different disciplines. Many of the problems that result from this communication breakdown can be avoided through exposing all engineering students to architectural graphics as part of the general engineering curriculum. In addition, benefits such as increasing student's creativity and motivation within the field of engineering are added benefits of including architectural graphics in the curriculum.

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Overview of Graphics in the Engineering Field

With an understanding of each area of engineering graphics, and their individual histories, one soon appreciates the complex interrelationship between them. The three main divisions of engineering graphics include *architectural, mechanical, and electrical/ electronic* graphics.

- *Architectural graphics* dates back to ancient times. In modern times, the *Information Age* has made possible the design of large and more complex structures. Typical structures designed using architectural graphics include buildings, bridges, towers, ships and many other structures. The methods of architectural representation include orthographic projection, plan and elevation views, and associated sections and details. Perspective drawings are commonly architecturally based.

  Additional architectural based graphics developed to fit within buildings include mechanical, electrical, pipe and ventilation systems. Without a basic understanding of the architectural design, it would be difficult to design components and systems of the main structure. Consider the analogy of the design of the structure as if it were a puzzle of interlocking pieces. If one does not have a clear understanding of the area a particular component will fit, then the process of design would be plagued with guesswork and inefficiencies.

- *Mechanical graphics* has also been used since ancient times. The industrial revolution saw a great increase in its use and development. Because it frequently involves the representation of objects usually smaller than those designed through architectural graphics, designs are commonly produced at or near full size. Basic mechanical drawings include detail and assembly drawings. Methods of pictorial representation include orthographic, axonometric and oblique drawing with associated details, sections and developments. Mechanical graphics is frequently taught as the only "engineering graphics", with architectural and electrical/electronics graphics omitted.

- *Electrical and electronic graphics* is the newest and currently largest member of the engineering graphics disciplines. In the last century there was a great expansion in the demand for electrical/electronic graphics, which has continued into the twenty-first century. Electrical/electronic graphics differs markedly from the more closely related architectural and mechanical graphics. Thus an engineer educated in electrical/electronics graphics may be unprepared to read architectural or mechanical drawings.

  Electrical and electronic symbology and drawings are not drawn to scale unless required by a machine or structure interface. The electrical/electronic engineering drawing includes block, line, schematic, wiring, terminal and logic diagrams.

Improving Graphic Literacy

The primary goal of any engineering curriculum should be to produce well-prepared engineers, ready to enter the work force. Beyond the fundamental principles of engineering, the exceptional engineer should be able to work well with other professionals to develop creative solutions for complex problems, and demonstrate a level of enthusiasm regarding their profession.

Incorporating architectural graphics into the general engineering curriculum fosters all of these strengths.

Although often viewed as discrete, the substantial overlap of engineering fields makes it imperative that engineers are trained with a common method of communication. The isolation caused by graphic illiteracy results in unnecessary redundancy and avoidable errors. The parent plans of lead architectural and construction teams commonly have an architectural graphic base. Further architectural, mechanical, and electrical design relies almost exclusively on the guidance, contract and arrangement plans. Literacy in architectural graphics enables engineers of all disciplines to function more efficiently.

The drawings bellow are used to teach first year engineering technology students how to read and make architectural based plans. Students may use these architectural plans to layout mechanical and electrical building systems.

Architectural Problems Used in Student Instruction

Figures 1 and 2 below are used in student instruction to expose students to common architectural scales.

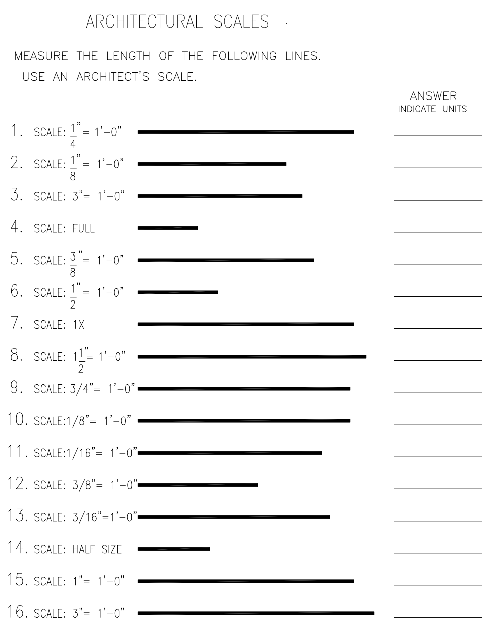


Figure 1

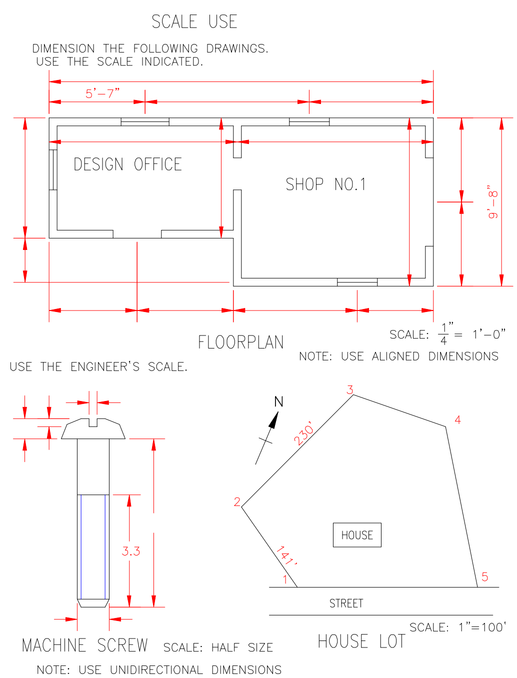


Figure 2

Figure 1 is used to help students recognize architectural scales, while Figure 2 requires the students to use the scales to define an object to be designed and constructed.

Making computer drawings, or copying and revising existing drawings aid the student in understanding computer use, building construction and engineering design. See Figure 3 below.

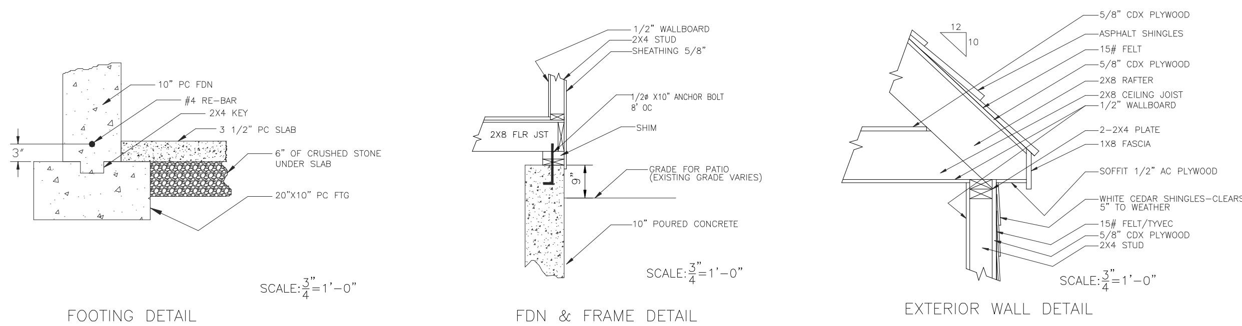


Figure 3

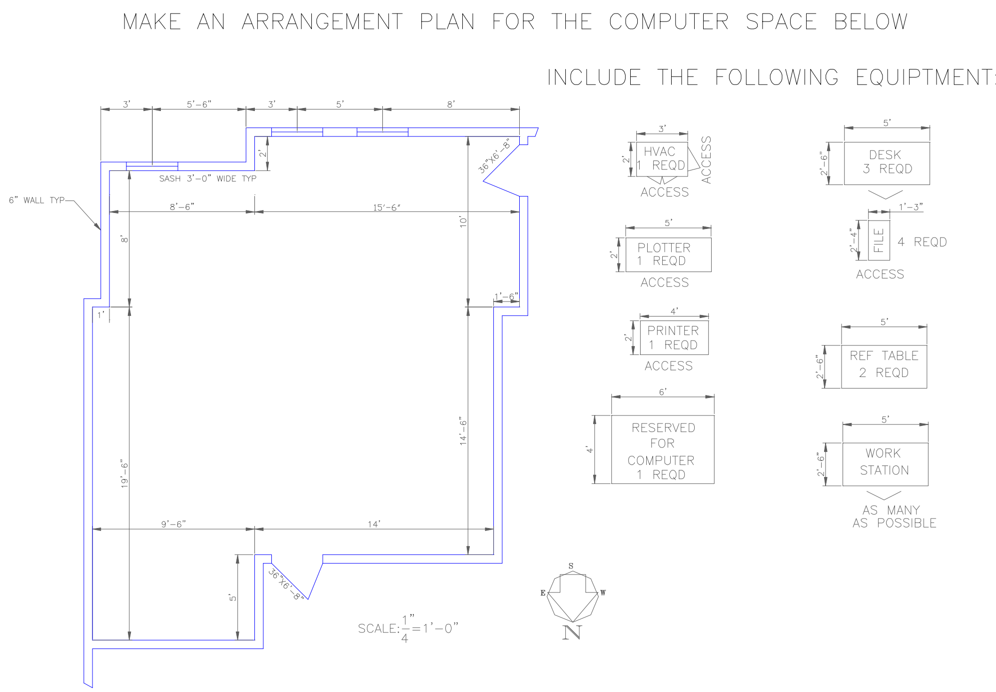


Figure 4

Figure 4 illustrates a short design problem. The student must make an arrangement plan of a computer room in an existing space. A goal of this design is to provide as many workstations as possible in the existing space.

Additional design problems may be developed using pipe and electrical systems. Figure 5 below illustrates this type of problems.

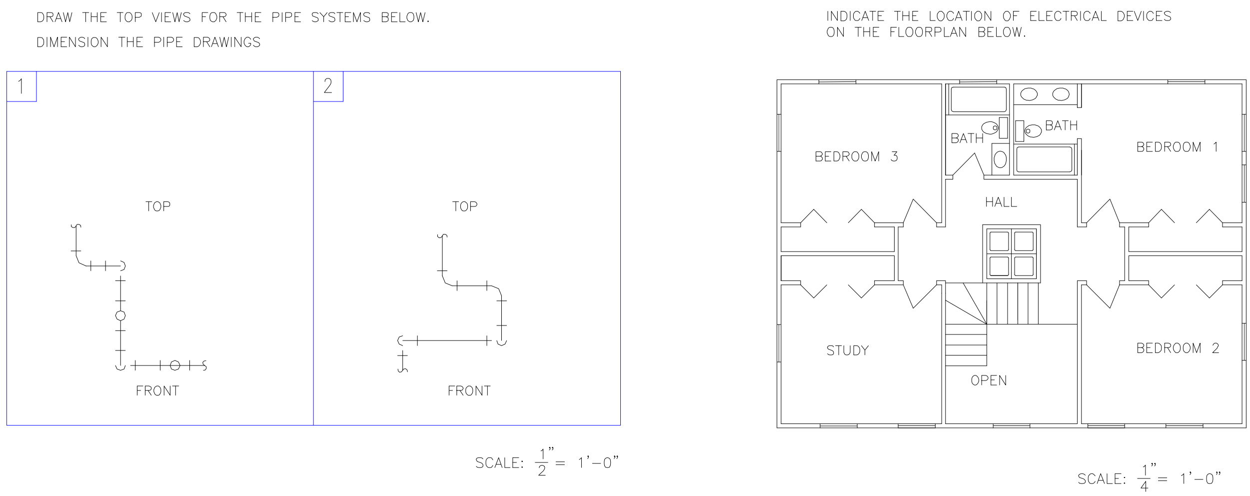


Figure 5

Architectural *solid modeling* also helps students to develop creativity and artistic skills. This can be accomplished by developing graphics design projects such as those illustrated in figures 6 and 7 below.

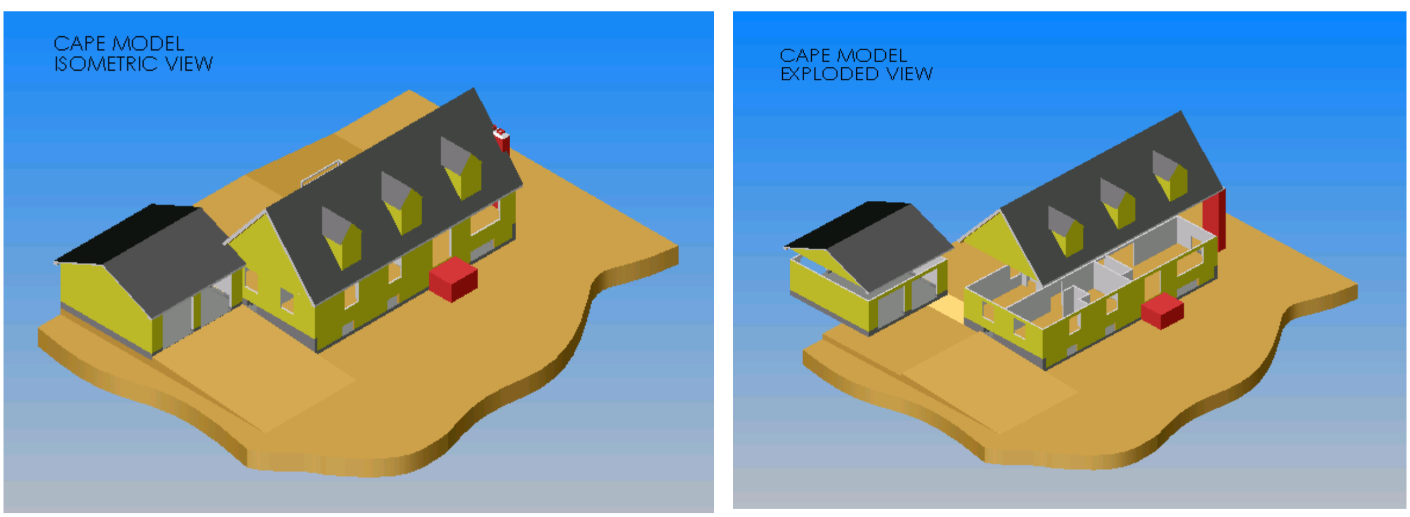
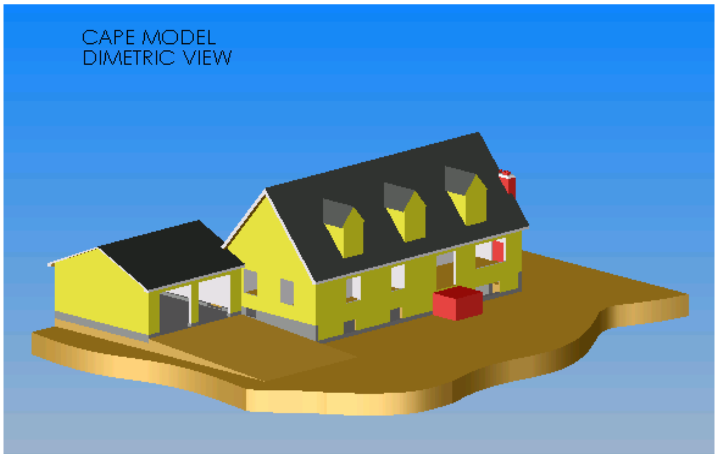


Figure 6. Isometric views of a Cape House



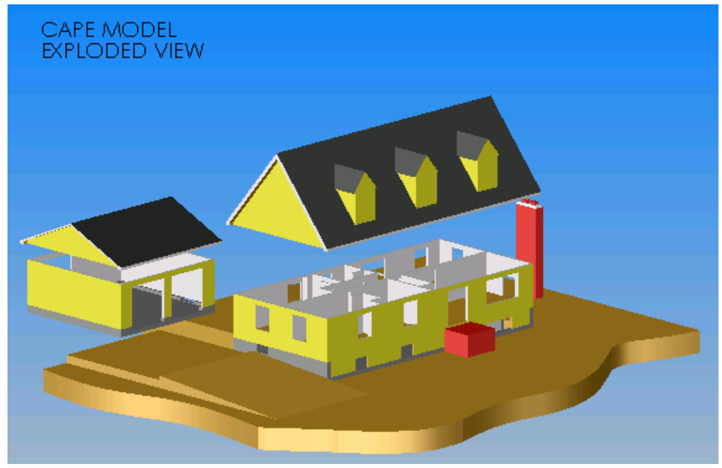


Figure 7. Dimetric views of a Cape House

It is poor practice, that while the Architectural Engineering and Construction Industry comprises approximately 10%of the gross national product (GNP) of the United States, many engineering students graduate without any instruction in architectural graphics. It is unfair to students to continue to focus on mechanical graphics education without also including architectural and electrical graphics.

The purpose of engineering graphics instruction is not only to teach a language of expression, but also to develop a student's ability to think creatively. Engineering graphics is in effect a tool by which to record creative thinking. The architectural education model includes emphasis on visualization, training in form and arrangement, rapid and accurate sketching techniques [1], perspective drawing and architecturally based computer software packages (i.e. AutoCad, SolidWorks). It is a comprehensive method of preparing engineers to enter the work force. The widespread use of freehand sketching, board drawing, and architectural based computer software is clear evidence of the industrial application of architectural graphics.

Many young engineers complain that they find the application of their work boring. This can often be attributed to their lack of appreciation of their contribution to a much larger project. Since graphics is a fundamental course that can familiarize students with all the major disciplines, it helps students to have a helpful understanding of the "big picture".
The knowledge of architectural graphics permits the engineering student to visualize how the engineering disciplines relate to each other within the graphic framework.

One method for introducing students to architectural graphics is to familiarize them with architectural based graphic publications. Examples of such publications are the Architectural Graphics Standards, Sweets Catalogues, Time Saver Standards, and national and state building codes. General and military specifications are also useful, particularly to familiarize the students with information used in advanced engineering design. Working plans and prints are a very effective way to provide students with practical experience in reading and making plans.

Conclusion

It is important for instructors of engineering to use the most effective methods possible to prepare students to enter the workforce. Including architectural graphics in the general engineering curriculum will prepare students for upper level courses, and employment in the engineering field. A deficiency in graphic education creates a vertical weakness in the engineering curriculum, as students lack a conceptual foundation that applies to the rest of their education. A horizontal weakness is also developed, as the engineer without a solid graphics background is unable to communicate across the engineering fields. A strong background in architectural graphics promotes a better ability for engineers to communicate between fields and aides in developing creativity and motivation. Graphics is the universal language that unifies the engineering profession. In fact, graphics provides a common language for communicating among applied and research engineering, engineering technology, designers, drafters and technically trained people worldwide.

References

1. Voland, G., "Engineering by Design", Addison-Wesley Longman, Inc., 1999, pp. 4-8, 14-16.
2. Bertoline, G., Wiebe, E., Miller, C., Mohler, J., "Technical Graphics Communication", McGraw-Hill Companies, 1997, pp. 41.
3. Luzadder, W; Duff, J. "Fundamentals of Engineering Drawing". Prentice-Hall Inc. 10th Ed. Englewood Cliffs, NJ. 1989.
4. Giesecke, F; et. al. "Modern Graphics Communication". Pearson Prentice Hall. Upper Saddle River, NJ. 2004.
5. Planchard, D.;Planchard, M. "Engineering Design with SolidWorks" Schroff Development Corporation Publications. 2003.

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