Curriculum Development for the Integration of Marine Design in a First-Year Engineering Graphics Course

Eric W. Hansberry
Associate Professor, Northeastern University,
Lynn Hansberry Mayo, M.S. CCC/SLP

Abstract

First-year students at the School of Engineering Technology and the Lowell Institute at Northeastern University have been exposed to the marine field. This paper will discuss how to integrate marine topics into an introductory design course. These examples have been carefully selected to follow an industrial format and introduce students to naval architectural and mechanical design. Curriculum development reflects educational research to ensure maximum benefit to students. By incorporating marine design into the curriculum, students gain fundamental engineering skills, an exposure to on-the-job industrial methodology, an understanding of interdisciplinary work, improved communication skills, and invaluable knowledge that will aid them in making informed decisions about their future careers.

Introduction

A comprehensive introductory graphics course should take regional industries into consideration during curriculum development. Engineering graphics is a fundamental communication medium used by technically trained people worldwide to design, construct and operate structures, machines or products. Given its universal nature, the subtle regional variations in graphics design are often lost in higher education. Subsequently, students may be left ill prepared to address engineering issues related to their geographical location. In addition, errors result second to limited training in applied graphics. Teaching maritime graphics at the introductory level is an ideal method to increase students' knowledge of fundamental engineering skills, expose them to on-the-job industrial methodology, increase their understanding of interdisciplinary work, improve their communication skills, and provide invaluable knowledge that will aid then in making informed decision about their future careers.

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. It is vital that universities prepare their students for the great variation of problems that they will encounter. The design effort is frequently hampered by the inability of an engineer to read the plans of his design or to read the interfacing plans of other engineering disciplines. This graphic illiteracy creates a schism in engineering not only between applied and research engineers, but also between engineers of different disciplines. A general knowledge and appreciation of the focus of each specialty is vital efficient communication.

An engineering graphics course must not only include overall, general information, but also specific examples that encourage a creative thinking process. A lesson in marine graphics is an ideal method to increase students' appreciation to the critical regional variations within their field, and coincidentally reinforces guiding principles that remain constant in engineering, across disciplines.

Educational Theory

As in all effective instruction, students should be provided with adequate breadth and depth of information to develop both interest and substantial background knowledge of a topic. The following techniques for educating students in this paper are taken from a curriculum that has been honed throughout over fifteen years of educating introductory level engineering students. Curriculum development follows 'Bloom's Taxonomy of Learning Theory,' and carefully addresses all six levels of cognition (knowledge, comprehension, application, analysis, synthesis and evaluation). Students develop their skills by first gaining the ability to recognize and recall facts, therefor developing basic *knowledge*. At this level they become familiar with the unique terminology and style of marine graphics. They then begin to process the material, as specific examples are presented to them, leading to the cognitive level of *comprehension*. At the next level, the *application* process, they are presented with real-life problems, and asked to apply their newly acquired knowledge. During this problem solving stage they are forced to reflect and participate in the next level of knowledge acquisition, *analysis*. The process of analysis leads to a *synthesis* of this new information, as students relate marine graphics to other land-based problems. Finally, this process leads to greater skills in *evaluation* and judgement, as they have successfully integrated new skills into their repertoire, and broadened their ability to become more effective engineers.

Although it is typical in American style education to expect that students will develop good analysis and problem solving skills when left to their own intuition, new concepts and connections are more often made when students are provided with explicit examples. Professors are advised to reinforce the relationship that marine graphics has with each of the main branches of engineering, as not all students will make this connection automatically. In this paper, specific examples of the methodology behind introducing marine design are presented, with an emphasis on its similarities and differences from the main branches of engineering. Finally, the benefits of including marine-based graphics in an introductory course are highlighted. Ideally, all of these concepts are explicitly stated to students throughout the teaching process.

General Overview of Engineering Graphics

The three main divisions of engineering graphics include architectural, mechanical and electrical/electronic graphics. All are integral components of shipbuilding. Constant reminders to students of the importance of general knowledge across specialties are essential, and this reality is clearly apparent in when analyzing the process of designing marine vessels.

Architectural graphics is generally used in the representation of large scale structures, machine or products. Examples include ships, buildings, bridges, towers, planes, pipe, vent, and cable systems. Architectural graphics has been used since ancient times, and has become increasingly important in modern times, as ship structures become larger and more complex. The methods of architectural representation include orthographics (plans and elevations) with associated sections and details. Additional methods sometimes used include perspective, and axonometric. Marine structural engineers employ architectural graphics in ship hull design.

Mechanical graphics is generally used to represent objects at or near full size for example, half or double size. Like architectural engineering, the field has grown steadily with the industrialization of society. Major mechanical drawing methods include detail and assembly drawings. Methods of pictorial representation include orthographic, axonometric and oblique drawing with associated details, sections and developments. In a maritime project, a mechanical engineer would design and solve problems relating to ship propulsion, (engines) piping, ventilation, winches, cranes, elevators and many other mechanical based designs.

Electrical and electronic graphics represent the largest of engineering disciplines, surpassing all others in the 1970s. This is the newest form or dialect of engineering graphics with most of its growth occurring in the twentieth century. Electrical and electronic graphics differs markedly from the more closely related architectural and mechanical graphics. Electrical and electronic symbology and drawings are not drawn to scale unless required by a structure or machine interface. The electrical and electronic engineer utilizes block, line, schematic, wiring, terminal and logic diagrams to design systems. An electrical engineer working on a ship design is responsible for wiring and cabling the ships from the engineer room to the antennae arrays.

General industry and the marine industry require that electrical engineers, designers and drafters read architectural and mechanical based drawings. Electrical engineers must be able to read architectural based structural drawings to run wire and cable. They must have an appreciation of ships' structural integrity in order to locate penetrations. Electrical engineers must be able to read architectural and mechanical based drawings in order to cable mechanical devices.

Marine Based Graphics Design

Marine-based graphics design is a specialty area that incorporates a variety of designs from all of the major branches of engineering. The specialist in marine graphics must be familiar with the different styles of communication in each branch, to interpret each other's designs. The demand for marine based design has declined in recent years. The marine industry is cyclical, responding to the needs of commerce and the military. Though the current demand for marine designers is low, the field has existed throughout the nations history, and the demand for design, repair and alterations will continue to ebb and flo with the industrial and military demands. No minor component of shipbuilding can be created in a vacuum, and educated communicators are the key to the successful completion of a project.

In institutions of higher learning located near bodies of water that are used for shipbuilding, repair or water transportation, it is especially important to include marine based engineering graphics into school curricula. This will familiarize students with the industry. Engineers not specifically specializing in shipbuilding may be called upon to design a component of a ship (i.e. an elevator), and a knowledge of the whole system will better prepare them in the design of their individual part.

Teaching Marine Based Design

Careful development and presentation of curriculum is essential for optimal learning of a new concept. Students are inspired when they are provided with actual ship designs, and any anecdotal information possible. Assignments are always related back to the main branches of engineering. Architectural based design drawings are assigned in an effort to encourage interest in and familiarity of the marine field. It is important that students appreciate the many ramifications of good design work in shipbuilding. For example, students should distinguish between a beam and a girder. They should know that a column and a stanchion are the same thing.

Clear distinctions between ship structure and a land building are presented throughout the course. Associated marine terms are discussed when plans are presented to the students. Students should become familiar with how a ship is constructed by utilizing deck, bulkhead, hull transverse and longitudinal section framing plans. General reference is made to marine terms such as: forward and aft perpendicular, length overall, length at the water line, station points, speed in knots, deck houses, and superstructure. A typical assignment requires the students to draw a frame foundation and size weld.

After students become comfortable with general design plans, they should then learn about alteration plans. Engineers of many backgrounds may be called upon to update or alter the ship's system. Since many vessels have a life span of up to fifty years, engineers are not only called upon for the original design, but also maintenance of ships. Often vessels are converted to perform a very different function from their original design. Therefor, a marine graphics curriculum should include exposure to both general arrangement plans and alteration plans. The general arrangement plans indicate decks, levels, platforms, innerbottom, and related structures. Arrangement plans also show students the location of ships' engine rooms, fuel oil tanks, pump rooms, cargo spaces, berthing stowage of all kinds, offices, shops (nuclear, electrical, etc.), and many other spaces necessary to run the ship.

Specific assignments for students working with alteration plans are explicitly related to specific fields of specialty when they are presented. Students work with existing ships' systems including lighting (electrical), pipe (mechanical) and heating, ventilation and air conditioning (HVAC). For example, changes in overall structure are presented as an architectural engineering problem. Electrical engineers focus on adapting or implementing new lighting. Changes in pipe and ventilation systems require the expertise of an engineer with a mechanical background. Much of this design work directly correlates to land based projects. Students enjoy the benefit of understanding how their knowledge applies to a new field of work.

The following problem demonstrates the relative ease with which a marine graphics lesson can be introduced into a typical graphics curriculum. In a freshman graphics course, much of the subject matter is traditionally mechanical based. Students using current texts gain experience in computer drawing machine parts that may be used in building tools, pumps, engines and many other mechanical devices. Shipboard pipe design is similar to land based design. Utilization of a marine pipe design acquaints the students with both land and marine applications. The following one line pipe design is an example of a plan presented to students. This example shows the x, y and z coordinates used in ship designs. Drawings like this provide practice in utilizing a different coordinate system as well as three-dimensional visualizations. A typical pipe design exercise requires students to make a plan view from the given elevation. Free hand sketching and computer aided design (CAD) are also included.

Local industrial support for marine graphics training ensures professors current industrial examples to be used in the classroom.

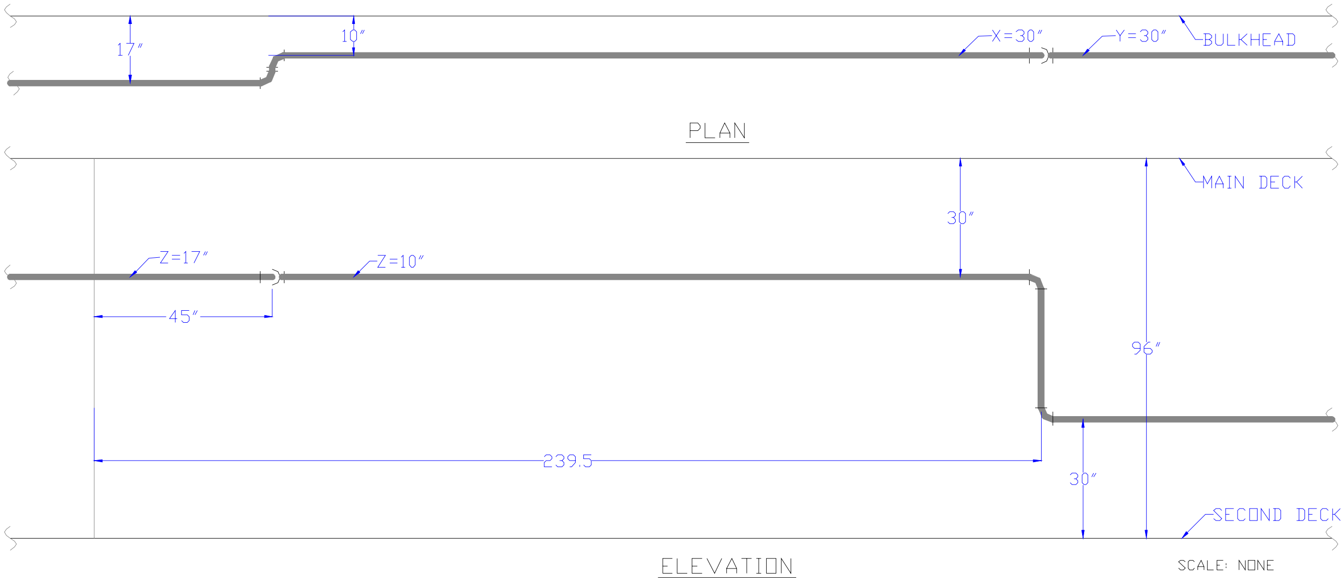

FIGURE 1

Benefits

One of the major and most obvious benefits of teaching marine graphics in an introductory level course is that it provides students with a wider knowledge base, making them more marketable within the industry. As professionals, we aim to not only prepare our students to attain employment, but also to stimulate curiosity, creativity, and a breadth and depth of knowledge essential to producing quality work. If a university is located in a maritime region, teaching maritime graphics should be of great interest. Students can begin to relate the information they acquire in the classroom with the world that surrounds them. As stated earlier, there is a direct correlation between marine graphics and other types of graphics, and therefore students not planning on a marine career will also benefit from this knowledge.

Of the many attributes that make up a successful engineer, perhaps three should be highlighted as most critical. Basic engineering skills are clearly essential, and can be acquired and enhanced in the process of studying marine design. Good interdepartmental communication and knowledge is paramount, and marine design projects exemplify the many specialties of engineering working together. Finally, creativity is the skill that most often sets one professional apart from others. Given a greater number of situations and problems to solve, students will further develop their ability to think creatively. A lesson in marine graphics improves basic design skills, critical communication skills, and generates more creative thinking.

Conclusion

Utilizing an industrial format in instructing first-year engineering technology students better prepares them to enter a broader number of positions in the work force. Creating quality professionals is a basic goal of higher institutions. Unfortunately, many first-year students have limited exposure to practical engineering and few opportunities to design within and across disciplines. At minimum, design projects presented in the industrial format using maritime examples acquaint students with the various architectural, mechanical, and electrical / electronic language and symbols. Well-structured assignments also encourage growth and self-confidence in the creative thinking process. In addition to providing this essential foundation of knowledge, employing the industrial format greatly assists students in their career development. Given multi-step projects, they become keenly aware of the importance of communication among specialties and the need for a general understanding of all engineering disciplines. This exposure to marine design through real-life projects affords them the opportunity to evaluate their strengths and interests to make informed decisions about their future careers. Introducing the industrial format during students' first year provides a safe environment for students to gain fundamental technical knowledge and invaluable lessons in career development.

1. Bloom, B.S. (Ed.) (1956) Taxonomy of educational objectives: The classification of educational goals; Handbook I, cognitive domain. New York; Toronto: Longmans, Green.

ERIC W. HANSBERRY
Eric Hansberry is Professor of Design Graphics in the School of Engineering Technology at Northeastern University. He served as Acting Department Head at the Franklin Institute of Boston. Professor Hansberry holds a number of professional registrations, including civil structural design and construction engineering (MA, NH), and mechanical design engineering (NH). He is a founding member of the National Society of Architectural Engineers and an Honorary Member of Tau Alpha Pi. Professor Hansberry holds B.S. and M.S. degrees in Civil Engineering from Tufts University and Northeastern University respectively.

LYNN HANSBERRY MAYO
Lynn Hansberry Mayo is a Speech and Language Pathologist in the Boston Public Schools, and in private practice. She holds certifications in both speech and language pathology and transitional bilingual education. Ms. Mayo specializes in the integration of recent cognitive research in curriculums for a diverse population of learners. Ms. Mayo holds a B.A. in Modern Languages and a M.S. in Speech and Language Pathology from Northeastern University.