Session 2438

ENGINEERING EDUCATION
DIFFERENCIES AND SIMILARITIES AMONG NATIONS

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ABSTRACT

The curricular content of various graphics courses will undergo changes relative to new methods for the engineering design process in industry. New graphical communication media have had an inevitable impact on the design process and require students and engineers to work in a new environment of virtual reality, in a modeling space rather than on paper space. Does this mean that the old concepts and methods of teaching engineering graphics and descriptive geometry courses should be discarded? After having a half-year experience of teaching introductory engineering graphics at Michigan Technological University (MTU) and previous long-time teaching experience at Cracow University of Technology (CUT), the author's intent is to have some input into the ongoing discussion in the field of engineering graphics education. This paper discusses basic similarities and differences in teaching engineering graphics concepts at the American and Polish universities. Some work from Polish students will also be presented.

INTRODUCTION

The 1997 Mid-Year Conference of the ASEE/EDGD focused on "This Year's Model" of the engineering graphics curricula. Discussions of this type are particularly valid in the United States, where new ABET criteria are currently being implemented. The Polish Seminar on "Modern Education of Geometry and Engineering Graphics", which takes place simultaneously with the ASEE annual conference, will provide a special forum for the discussion of the engineering graphics curriculum in Poland for the next century. Educators in the European countries are faced with the same problems as in America and the curricula of the respective courses must change continuously. Educators in the field must follow the general trends in changes in engineering design processes and update the curricula accordingly. Barr [3] states that "the field of engineering design graphics has been a cornerstone in engineering education for over a century." Ault [2] makes a valuable analysis and comparison of various American graphics courses in terms of content, level and credit. The question is: What does graphics education look like in my home country, at my home university, and is there a significant difference between our countries?

Different surveys have been conducted to help evaluate the different types of graphics courses. We are aware of the fact that a diverse and wide body of knowledge has been covered with a general, common title, engineering graphics. A crucial question was asked by Ault during the Madison conference: Do students still need to understand the concepts of conventional graphics in addition to those needed for a new curriculum in geometric modeling? This basic question should certainly not be left unanswered.

WHAT IS SIMILAR AND WHAT IS DIFFERENT?

The future tendencies and directions in engineering design are not only a matter of the concern for our American colleagues, but also for all educators in the graphics field, regardless of the country in which they teach. The difference between European and American projection methods, a first and/or third angle orthographic projection, is no longer important, if we teach our students how to understand three-dimensional space and help a student to “see” and to “think” in three dimensions. This educational goal may be achieved by using different methods and means.

The teachers of engineering graphics today tend to use, if not overuse, CAD/CAM software in the educational process. Sometimes it is assumed that computer graphics software is the primary means that will enhance a student’s spatial visualization ability. On the contrary, recent research [8] provides data to prove that the influence of computer graphics on the enhancement of spatial ability is not so direct and straightforward. Electronically created tutorials on web pages, instructional movies and CD interactive media are nowadays produced to the advantage of engineering graphics students. We should probably ask ourselves if the amount of time it takes to produce these materials is directly related to the benefits received by the students. Today it is popular to have the lecture content delivered on a www page. I agree that computerized materials delivered on a www page are of the utmost convenience for students. What we really must remember is that whatever we write and deliver to the students, has to be as correct, concise and as clear as possible. Instead of delivering a new computer image on a www page, would it not be better to let the student work with a real model? Shouldn’t we give the student a chance to build his/her own model? Why don’t we let the student work with the set of blocks as done by Sorby [13] during her special visualization course? Sets of blocks are not nearly as expensive as the required computer programs. We have observed that in some Japanese universities, students not only build virtual, computer models, but they simultaneously make physical models of the designed objects [1]. We should let the student build his/her own psychical model whenever possible.

Even abstract problems in descriptive geometry such as auxiliary view planes and the projection of points, lines and planes on these view planes are a big problem for a student to visualize. In my courses, students were allowed to manipulate their own drawings and were encouraged to fold back the sheet of paper along the fold line to see that “mysterious” auxiliary view plane. Once the student had done it, it was no longer a problem for him or her to understand and conceive what we were speaking about. We should refrain from teaching step by step constructions, with no true explanation of the visual concepts behind the 2-dimensional drawings. As Slaby [12] says: “The use of computers in graphics and descriptive geometry should be introduced after the students have worked [..] on the theory of descriptive geometry through drawings on paper and model making.” I have found that students have encountered enormous problems when jumping between drawing problems and computer assignments.

It is obvious that in my country of Poland the opportunity to get access to modern computers and software is not as straightforward and as easy as at American universities. Does this mean that we do not teach graphics efficiently enough or that we lag behind our counterparts from the high technology countries? A short description of the relevant courses from our graphics curriculum in Poland follows.

GRAPHICS CURRICULA AT THE CUT

Generally, Engineering Graphics (EG) at the Polish technical universities is covered in different courses, which are delivered under many various titles at the freshmen level. Among others there are:

Descriptive Geometry (1 lecture hour + 2 laboratory hours per week) with the following topics:

- geometric constructions
- theory of projections
- invariants of different projecting methods
- reading engineering drawings
- isometric and oblique projections
- Mongean projections: views of points, lines and planes
- auxiliary view planes
- true length of a line (auxiliary view plane & revolution methods),
- true shape and size of a plane (auxiliary view plane & revolution methods)
- conics' theory and constructions
- point of intersection between: a line and a plane
- line of intersection between two planes (auxiliary view plane & cutting plane methods)
- plane and a cone or a cylinder intersections
- sphere and its intersection with a plane
- radial and parallel line developments
- solids intersections (right circular cones and cylinders)
- perspective drawings - basics

Engineering Drawing (1 or 2 laboratory hours a week)

The course is designed to teach a student how to correctly create a technical drawing using basic technical instruments like a bow compass, a straight-edge, and how to correctly apply standard lettering and line types, dimensioning, and tolerancing to the drawing.

The above mentioned courses are compulsory and are offered at the freshmen level.

Some majors have offered modified courses. For example the sophomore students in the field of Management and Organization major must take a course in **Computer Engineering Graphic**s [5], which does not cover any typical descriptive geometry problems, but which delivers the fundamental science for technical drawing and computer graphics. This course has been developed for 2 hours per week of laboratory instruction. The problems covered in the course include the following:

- coordinate systems in computer graphics
- creating engineering drawings
- sketching
- computer representation of a 3D model: wireframe, surface and solid models [10]
- Boolean algebra application into modeling
- theoretical basics for computer geometry [11]
- B-splines, NURBS, Bezier curves: theory [11]

- homogenous co-ordinates
- dimensioning
- rendering
- animation: *.fli and *.flc files
- CAD software: AutoCAD r.12, 3D Studio,
- Turbo Pascal and graphics procedures

During the second part of the course, in the summer semester, students have a chance to utilize graphical procedures of Turbo Pascal for an individual design project, which is to design a part of a finite element mesh.

At the junior level, an elective course using AutoCAD is offered. The course consists of two-laboratory hours per week.

In figures 1-4, some examples of the Polish students' works are presented to illustrate the types of assignments given to the students in the course. The topics covered in the courses are fairly close to those presented in the Ault paper [2]. The question of equipment (hardware and software) availability still remains. There is still wide gap between our countries in this respect. Optimistically, I assume that parametric, feature-based CAD software will be readily available in Poland in the next 5 years. The cost of the software and the required hardware places a barrier on utilization of such programs as Pro/Engineer, Mechanical Desktop, Micro-Station, I-DEAS or even CADKey. In the meantime, educators in Poland teach engineering graphics courses starting with descriptive geometry concepts and generally work from an eye-mind- and hands foundation to the benefit of the students. A lot of hand-made sketches to illustrate the design are made. After completing the basic course, students are able to take an elective/compulsory course in Computer Graphics, which uses AutoCADr.12 together with 3D Studio software and/or the graphical procedures of TurboPascal.

CONCLUSIONS

Detailed examination of various engineering graphics courses allow us to make a general conclusion. The proper balance between theory and practice should be attained. Teaching should relate to the students' abilities. This is why I find the testing and teaching concepts developed by Sorby [13] to be valuable and appropriate. The idea of pre-testing students on their spatial visualization abilities enables positive selection of those who lag behind their counterparts. The special spatial visualization course provides the student with the opportunity to develop his/or her skills and to study basic concepts of graphics and geometry. This helps the student to understand the spatial relations between 3-D objects in 3-D space. It also enables the "tabula rasa" student to overcome his/or her deficiency. A broad gap can be observed between those students who come to the university having had a graphics course at the high school level and between those who have not previously taken any such courses. The students with no previous experience have problems with proper drawing technique using such instruments as a straightedge, a triangle and a bow compass. To fill the gap between the two groups is our task. These observations refer not only to Polish but also to American students.

At the end let me be allowed to cite Prof. Steve Slaby [12] who recommends that we do not just train the students, but that we teach them. Modernization of engineering graphics courses cannot be attained merely by latching on to computer aided design. Basic skills and creative thinking should be the goal of engineering graphics education. When teaching a subject, we should try to build a curriculum which is concise and logical and is relevant both to the students and to the needs of industry. To enhance visualization ability, students should have the chance to practice and to sketch a lot of isometric and oblique pictorials. For architectural majors it is important to be able to make perspective drawings. It is obvious that computers will largely replace hand-drawn designs and that they play an important role in engineering design process today. However, are they a true substitute for hand-made drawings and for the concepts born in person's imagination?

One general question remains unanswered: How can we cover all this in a single three-credit course?

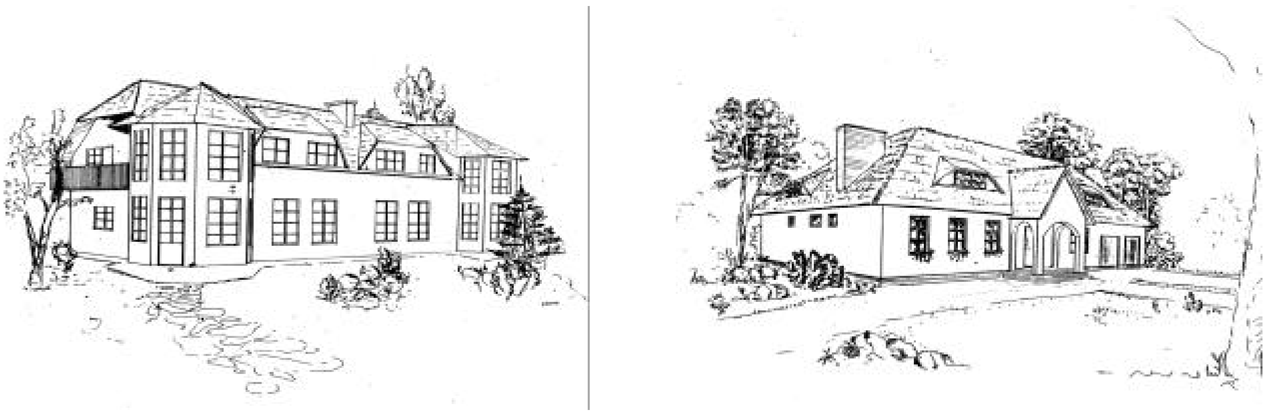

Fig.1 Two examples of a perspective, hand-made drawings of the family houses made for the visualization purpose (Faculty of Architecture)

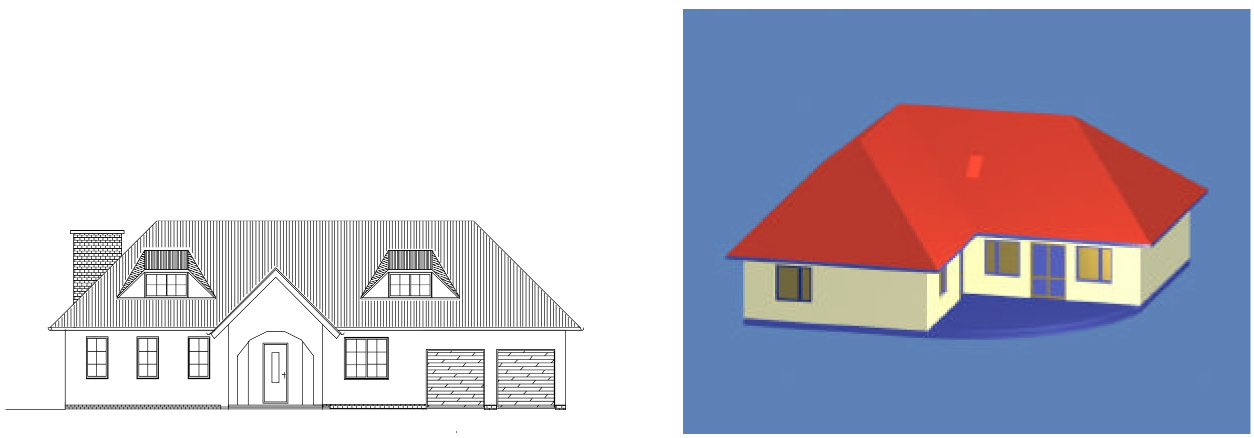

Fig. 2. Computer generated elevation and a rendered axonometry of a design project.

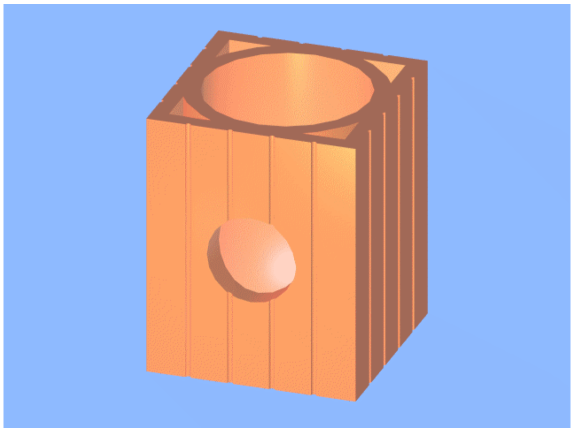

Fig. 3. On the site- project realization.

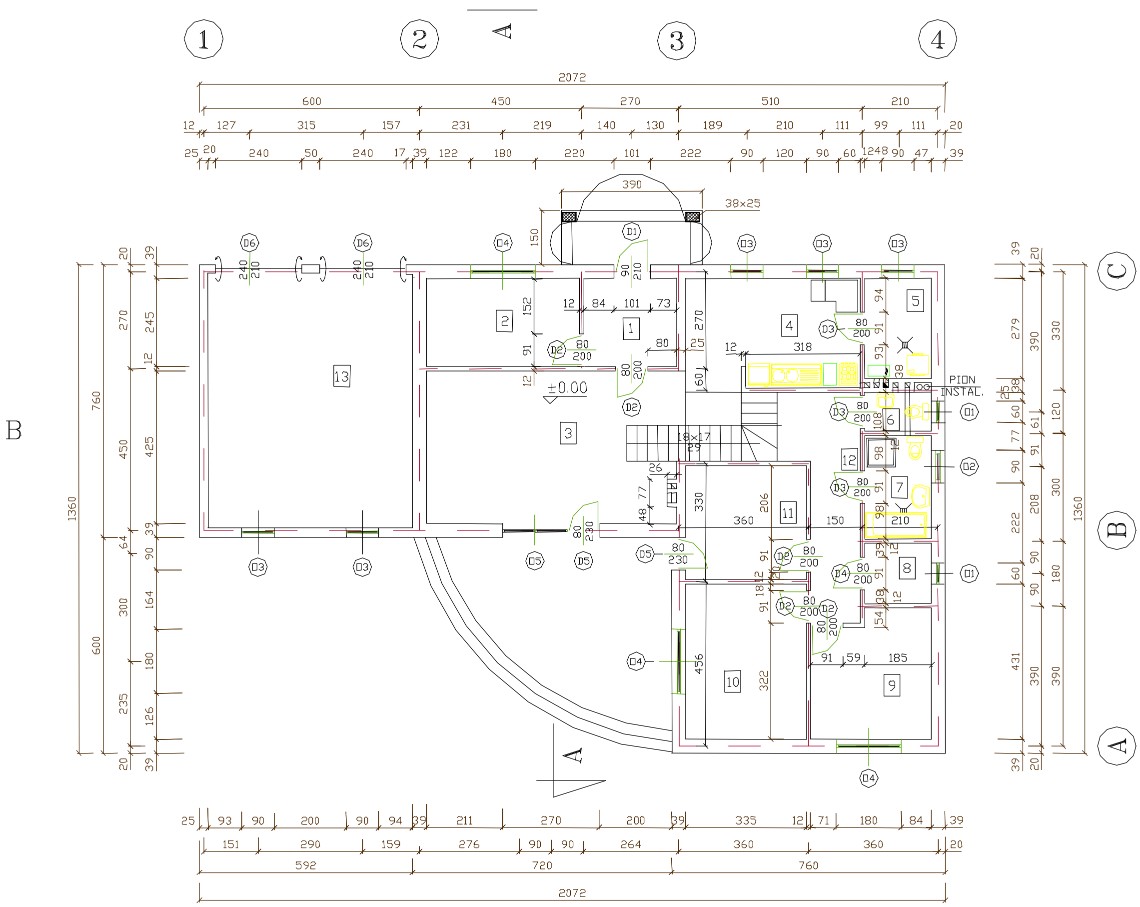

Fig. 4. Computer Aided Design of a ground floor plan.

REFERENCES

1. Araki, T., *Basic Education of CAD/CAM Though Multimedia and Network Aid*, Proceedings of the 7th ICECGDG, Cracow, 18-22 July 1996, pp.534-538

2. Ault, H. (1997), *Principles of Parametrics – New Concepts for the EDG,* 1997 ASEE/EDGD Mid-Year Conference, Oct. 24-26, 97, Madison

3. Barr, R. (1997)*, Planning the Engineering Design Curriculum for the 21st Century*, 1997 ASEE/EDGD Mid-Year Conference, Oct. 24-26, 97, Madison

4. Bertoline, G.R., et al., *Technical Graphics Communication*, McGraw-Hill Companies, 1997

5. Gorska, R.A., *Computer Engineering Graphics Course Curriculum and Realization, PSG&G Journal, 1997*

6. Gorska, R., Sorby, S., *Gender Differences in Visualization Skills – An International Perspective*, 1997 ASEE/EDGD Mid-Year Conference, Oct. 24-26, 97, Madison

7. Juricic, D., *New Developments in Engineering Design Graphics EDG with a CAD/CAM Component*, Proceedings of the 7th ICECGDG, Cracow, 18-22 July 1996, pp.318-322

8. Leopold, C., Sorby S., Gorska, R., *Gender Differences in 3-D Visualization Skills of Engineering Students*, Proceedings of the 7th ICECGDG, Cracow, 18-22 July 1996, pp.560-564

9. Manner, K., *ME 232, Geometric Modeling for Engineering Applications, http://www.cae.wisc.ed*

10. Rodrigues W., *The modeling of design ideas, Graphics and visualization techniques for Engineers*, McGraw-Hill Book Company, 1992

11. Rogers, D., Adams, J., *Mathematical elements for computer graphics*, McGraw-Hill Publishing Company, 1990,

12. Slaby, S., *Modernization of Graphics Curriculum,* Proceedings of the 6th ICECGDG, Tokyo, 19-23 August 1994, pp.523-528

13. Sorby, S., Manner K., Baartmans, B., *3-D Visualization for Engineering Graphics,* Prentice Hall, New Jersey, 1998

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