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Visual Communication Curricula for the Global Engineers

Nastava vizualnog komuniciranja za svjetske inženjere

SAŽETAK

Uvođenje studenata u inženjersku profesiju počinje razvijanjem sposobnosti komunikacije, posebno grafičke. U ovom radu autori iz različitih dijelova svijeta uspoređuju svoju sadašnju praksu predavanja sadržaja inženjerske grafike (nacrtna geometrija, ručno tehničko crtanje, crtanje slobodnom rukom i računalna grafika te CAD-programi: Auto CAD...) i pokušavaju zacrtati put koji bi mogao slijediti nastavni plan u budućnosti. Oni predlažu što treba ostati kao princip vizualne komunikacije, a što treba mijenjati.

Ključne riječi: inženjerska grafika, računalna grafika, nastavni pan, budući inženjeri svijeta

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Visual Communication Curricula for the Global Engineers

ABSTRACT

The first step in introducing the engineering profession to students is to develop good communication skills, especially graphics communication. In this paper authors from different parts of the world compare their current practices in delivering Engineering Graphics units (Descriptive Geometry, Manual Technical Drafting, Freehand Drawing Computer Graphics and CAD programs: AutoCAD.) in an attempt to map a path which the future curriculum in this area may follow. They propose what will stay as principles language and what is going to change.

Key words: engineering graphics, computer graphics, curriculum, future global engineers

1 Introduction

Apart from the ability for excellent written and oral communication, engineers have had their own visual language - drawings. Computer technology has significantly changed the teaching philosophy of engineering graphics over the past two decades. We envisage that visual communication abilities of future engineers will continue to evolve in the next twenty years with an emphasis towards more interdisciplinary skills. A greater volume of information will be provided in a visual form with the use of drawings, charts, and diagrams. This will often be accompanied by the use of sound and motion.

Engineers today are the creators of the physical world, not just in their own country but of the whole world which is like a huge site, where they move from one project to another, from one country to another. To identify the profile of a global engineer and to create a curriculum which will produce such an engineer is a task of high priority of universities around the world.

Engineering futurists believe that change is occurring at such a rapid pace that the knowledge we teach our students today will be outdated by the time they graduate. Furthermore, as engineers, they will need to change their occupation several times throughout their working life. Australian writer Peter Ellyard argued that 70 per cent of professions that will exist 20 years from now do not as yet exist. We have already experienced the rapid development of new engineering fields (such as mechatronics and biomedical engineering) and seen a significant drop in enrolment in some of the more traditional engineering disciplines.

The whole industry will shift as a result of the move into a globalised, post-industrial society. This is a transition that we have to understand and adapt to. We have to go beyond the point of self-interest and envisage the future shape of an engineer. In so doing, we can create a new teaching founded on the basic principles underlying each engineering discipline.

Much research has been undertaken worldwide to outline a set of criteria that will be required of the future global engineer. The recent UNESCO report [1] pinpointed the need for dramatic changes. It suggested four points that must be reinforced as part of the reformation of education in the next millennium. According to this report, learning must satisfy the following criteria:

1) enhance the quantity/quality of knowledge,
2) develop initiative,
3) nurture the development of self and
4) encourage teamwork.

Yerlici [2] proposed a similar philosophy; that higher education should accomplish the following:

1) improve the ability to question and seek answers;
2) sharpen attention to detail;
3) refine the mind for greater sophistication at interpreting data; and
4) encourage independent thinking.

In addition, Yerlici stated that while providing basic knowledge, good teachers should stimulate the minds of students in the direction of critical thinking and creativity.

Professor Evan Pretty suggested the following in *Vision 2020- Education in next millennium* [3]:

1) Active learning should be emphasised over passive teaching to promote deep rather than surface learning;
2) Curricula and assessment systems should be redesigned to enhance critical thinking and problem solving skills as well as develop creativity and communication skills;
3) The role of the university teacher must undergo change from a ’lecturer’ to a manager of the education process - in other words, the sage on the stage will become the guide on the side; and
4) Students will have a wide choice of courses that may be undertaken ’at a distance’, therefore flexible courses for resource based learning will become a necessity.

The student/staff ratio has been increasing rapidly in past few years. However, the importance of the professor’s job will not decline [4]. There will always be a need for professors who can guide and motivate students in their course.

2 Engineering graphics curricula – present situation

Good communication skills are emphasized in all new strategies for creating a curriculum that will build a global engineer. Drawings are, and will continue to be, a major tool for engineers worldwide. The prevalence of computer technology has had crucial implications for teaching engineering graphics.

At present, significant differences exist globally in the delivering of knowledge in this area. The developed nations, which are well equipped with information technology infrastructure, have been exposed to permanent changes in teaching philosophy. This is in contrast to many educational systems, especially in the developing world, that have stagnated largely in traditional frames. In some of those systems, the instructor is still seen as an expert who imparts knowledge to students who, in turn, are expected to absorb the information without much critical thinking. The relationship between students and the lecturer(s) are rigid. Those systems are also characterized by overloaded curriculums and an emphasis on individual work in the learning process. Some of the didactical models are too mechanistic and therefore will not satisfy today’s and especially tomorrow’s more active learners.

In other developing countries education is modernized. There is no more unidirectional imparting of knowledge by an “expert” on a particular discipline

In Europe the classical knowledge are appreciated but computer sciences are developing as well, in many institutes. New disciplines are appearing, like computational geometry, CAGD [8], and the old ones are transforming. Ideas for the future were suggested in SEFI seminars [9] and the links between geometry and CAD are expected to increase in importance. Very sophisticated packages for construction calculations are reality in engineering. Actual development of engineer constructions is due to theory of constructions development and computer technologies, new materials and new architectural and constructive results [6]. In Europe engineers use of many professional CAD packages. Professors use software for scientific and professional work, like *Mathematica*, *Cabri*, *Maple* and educational software, made by professors at universities.[1]

[1]Prof. Seybold introduces Computer aided geometry (CAG), which is dimension independent. O. Giering, H. Seybold: KONSTRUKTIVE INGENIEURGOMETRIE, Carl Hanser Verlag, München.

Use of more powerful software requires more knowledge in users, including geometric knowledge.

Computer graphics and CAD are teached at universities in different ways [2], [6]. In Slovenia is active Society for higher didactic [3]. In Croatia, University of Rijeka the researches[4] are made on the quality of university teaching [7] aimed to adapt to the rapid change of technologies. Knowledge is considered as open, dynamic system. University organise many scientific tribunes on education with guests from Universities in Croatia, England, Italy, Slovenia and University of Connecticut, USA.

Table 1 illustrates four different curriculums from four parts of the world.

3 Future Directions

Our upcoming students will expect more active ways of seeking knowledge. New techniques have to implement more experimentation, exploration, testing of ideas in reality, exchanging of ideas with peers in small group activities, simulation, project based learning, life-long learning, critical thinking, and research skills. Collaboration and teamwork are powerful forces in the learning process and must form a part of every curriculum. Teachers are expected to undertake the role of facilitators in the learning process. The learning process is moving towards a more informal style of learning or self-directed learning where students are encouraged to teach themselves. It will increase the student's responsibility for individual learning results and empower the learner not to be dependent on the instructor.

A new, less formal approach can be developed to teach visual communication skills through the critique of established views. Instead of teaching in isolated units, knowledge can be disseminated through real design projects in a unit that students from different disciplines may enrol in. Good visualization skills will empower new engineers to be creative in their designs and influence their vision of the future world in the new millennium.

4 Principles of visual communication

What are the principles of visual communication language that will remain which engineering graduates need to understand in order to be equipped for professional practice in the new millennium?

The principles that we believe future teaching philosophy must incorporate are as follows:

1) Principles of visual science: geometric projections, space perception;
2) International Standards for technical drafting for different disciplines; and
3) Drawing techniques: freehand sketching and computer aided drafting.

First, **Principles of visual science** are taught in Descriptive Geometry. The main knowledge students should gain from this unit include good visualisation skills and how to present 3D object on 2D media and vice versa. Computer technology renders the teaching of unfriendly, tedious geometrical construction methods obsolete. Information technology has the potential to solve many of these problems. Education in the future will undertake an interdisciplinary approach to equip students with a wider base of knowledge so that an understanding of all parts is gained rather than a narrow specialisation in a particular area.

The very basics of Descriptive Geometry - the philosophy of projection, types of projections, 2D presentations, 3D presentations, sections, and details - will be sufficient for students to learn some techniques in freehand sketching and to start to draft using computers.

In Europe, principles of visualization will be constructive geometrical thinking, CAG, CAGD. In Europe many lecturers think that before CAD, future engineers will need general geometric ideas, concepts and methods, the ability of 3D thinking and geometric reasoning, to bee able to solve new problems, using new technology. The theoretical 3D solution has to be finished in the mind beforehand.

Second, **International Standards** for computer aided technical drafting for different disciplines do not as yet exist. It is our hope that in the new globalizes engineering arena international standards will be created in the next 20 years, which educators can introduce to students worldwide.

Third, **Drawing techniques**. Engineers today do not draft. Engineers sketch ideas while designing, or to provide explanations to other people. On some occasions, engineers do simple drawings using the computer, but the main job

Prof. dr. Stachel's programs CADDG, CAD3D, CAD2D for TU Win are permeated and mentioned in the book: G. Glaeser , H. Stachel: OPEN GEOMETRY, Springer Verlag, 1999.

[2] Through geometric and informatic educatin , CAD courses, or through introduction in computer graphics: Zámožik J., Richtáriková D., COMPUTER AND GEOMETRY, Special SEFI European Seminar od Engineering Education, Bratislava, 1997.

[3] "Slovensko društvo za visokošolsku didaktiku" you can find on http://www.fe.uni-lj.si/ sdvd/welcome.html

[4] "The Quality of Teaching in Higher Education" project: http://www.pefri.hr/Projekti/00913/

Table 1. Different curricula from four parts of the world

	University of Western Australia **Perth, Australia**	**Bogazici University** **Bebek Istanbul, Turkey**	**University of Santo Tomas** **Espanã, Manila**	**Ateneo de Manila** **University Loyola Heights,** **Quezon City**	**The University of Rijeka,** **Croatia**
COMMON TO FIRST YEAR	- Civil - Mechanical - Materials - Environmental	- Civil - Mechanical - Electrical - Computing - Industrial - Chemistry	- Civil - Chemical - Mechanical - Electrical - Electronics and Communications - Industrial	- Electronics - Communications and Computers	- Mechanical - Shipbuilding similar first year - Electrical - Civil
INTRODUCTION TO ENGINEERING PROFESSION UNIT (which comprises visual communication and oral/written communication units)	**Project Engineering 115 (PE 115)**: -Lectures 1hr/week/2 sems (given by professors from each discipline); **- Engineering Drawing** *4hrs/week/1 semester* **- Written/Oral Communication** *1hr/week/2 semesters* (on how to write technical reports, resumes, how to give oral presentations); **- Practical Project Work** (projects on each department-duration of each project 5 weeks).	**Introduction to Engineering** (offered by each department separately): 3hrs/week/1 semester **-Graphics (ENGG 110)** *3hrs/week/1 semester* **-Turkish (TK 221, TK 222)** *2hrs/week/2 semesters*	(There is no *Introduction to Engineering Profession* or *Introduction to Engineering unit.* Visual communication units are separate units). *Oral/Written Communication Unit:* First semester: **- Comm. Skills 1 (Eng 101a)** *Lectures, 3 hrs/week* Second semester: **- Comm. Skills 2** *Lectures, 3hrs/wk/sem*	(There is no *Introduction to Engineering Profession* or *Introduction to Engineering unit.* Visual communication units are separate units). *Oral/Written Communication Unit:* **- Communication** Across the Curriculum I & II (En 11 En 12) *Lectures, 3hrs/wk/sem*	(There is no *Introduction to Engineering Profession* or *Introduction to Engineering unit.* Visual communication units are separate units). *Oral/Written Communication Unit:* **- English Language**
VISUAL COMMUNICATION UNITS	**Engineering Drawing** (as part of PE115): -Lectures, *1hr/week/1 sem* -Tutorials: . freehand sketching and manual drafting *2hrs/week/1 semester;* . AutoCAD *1hr/week/1 semester*	**Graphics (ENGG 110)** -Tutorials: *3hrs/week/ 1semester* (Lectures incorporated into tutorials)	**- Engineering Drawing DRAW 111/CAD** - Tutorials, *3hrs/week/1sem* (Lectures incorporated into tutorials) . mechanical drafting *2hrs/week/1st semester* . AutoCAD R14 *1hr/week/1st semester*	**- Technical Drawing/Drafting (ECE 11)** - Tutorials, *3hrs/week/1 sem* (Lectures incorporated into tutorials) . mechanical drafting *3hrs/week/1st semester*	Mechanical **- Engineering Drawing** *3hrs/week/1 sem* **- CAD** *2hrs/week/2 sem*

			- Engineering Drawing 121 (Draw 121/CAD) Prerequisite: Draw111/CAD - Tutorials, *3hrs/week* (lectures are incorporated into tutorials) . mechanical drafting *2hrs/week/2 sem* . AutoCAD R14 *1hr/week/1 sem*	**- CAD and Drafting (ECE12)** Prerequisite: ECE 11 - Tutorials, *4hrs/week/summer*	Civil **- Descriptive Geometry** - Lectures: *3hrs/ week/1 sem* - Tutorials: *2hrs/week/1 sem* **- Applied Geometry and CAD** - Lectures: *2hrs/week/2 sem* - Tutorials: *2hrs/week/2 sem*
VISUAL COMMUNICATION UNIT'S OUTLINE	- Basics of Descriptive Geometry - Introduction to technical documentation - Australian Standards - Technical Illustrations and Diagram - Fast sketching - Artistic Drawing - Computer Graphics-AutoCAD	- Multi-view projects - Sectioning - Dimensioning - Fasteners - Isometric - Assembling - Computer graphics-AutoCAD	- Lettering - Geometric Constructions - Isometric/Multiview projections - Section Views - Auxilliary Views - Lateral Development - Two Point Perspective - Screw Threads/Bolts and Nuts - Working Drawings - Computer commands in AutoCAD	- Lettering - Geometric Constructions - Isometric/Multiview projections - Section Views - Auxilliary Views - Lateral Development - Two Point Perspective - Screw Threads/Bolts and Nuts - Working Drawings - Computer commands in AutoCAD	- Descriptive Geometry - CAG - Computer Graphics-Geometric transformations in CAD - CAD Modeling - Surfaces - Surface modeling in CAD - AutoCAD, Design CAD - Terrains
ASSESSMENT	There is **no final exam**. There is a visualisation test at the beginning and at the end of semester. *Final mark is based on:* - Weekly Assessment (on the work produced each week in tutorials) - Average mark for the Assignments - Mark for the final Portfolio - Self-assessment	There is a **final exam**.	There is a **comprehensive exam**. *Final grade is based on:* - weekly activity or exercise produced each meeting - comprehensive examamination - hands-on examination in AutoCAD	There is a **comprehensive exam**. *Final grade is based on:* - weekly activity-work produced each week - comprehensive examination - hands-on examination in AutoCAD and project incorporated with another subjects, Engineering Practices and Workshop	There is a **final exam** (written and oral). *Final mark is based on:* - weekly activity-work - individual exercise - written and oral exam - hands-on examination in AutoCAD or Design CAD. Written exam can be replaced by two partial exams-colloquiums.

is the responsibility of draft-persons. However, an understanding of drawings is crucial for the engineer for their own visualisation purposes and so as to clarify to others; for example, clients or builders.

In some countries engineers still draft, if necessary. In Europe they use specialized software. But when they use some general CAD program solving new engineering problems, they combine and adapt their knowledge and ideas in the virtual 3D-computer space. Draft persons can not do it.

5 Teaching philosophy

Based on the principles of visual communication, the teaching philosophy for the future curriculum must incorporate the following issues:

1) Self-directed learning and life-long learning skills
2) Flexible curriculum
3) Face to face/"Virtual" education
4) Multidisciplinary approach
5) Collaboration

Self-directed learning and life-long learning skills. Future developments are difficult to predict and continuous learning, a life long process, is one of the solutions to ensuring that an individual can adapt when new situations arise. Life-long learning includes formal and informal experiences, such as attending formal courses, and self-directed learning through the Internet. Information technology (IT) can be harnessed to foster greater interaction and collaboration among students and teachers as well as between students themselves. IT has the potential to provide a more varied, effective and efficient learning environment [4].

Volitional control of the learning process by students rather than by the teacher will develop in students a more serious attitude towards the course. They will voluntarily seek more information. Having the freedom to choose the time and the place for learning will enable students to take greater responsibility over their own learning. In this manner, students will be nurtured to become more active and creative learners.

Flexible curriculum. As an environment for learning, universities today are at a crossroad. An increasing number of universities are adopting flexible forms of delivering knowledge. A flexible curriculum is accompanied by a shift towards outcomes-based teaching and assessment where the emphasis is on what skills and knowledge are learned rather than the content taught. The curriculum should be designed to develop critical understanding, analytical and problem solving skills, as well as a capacity for creativity. Students will have to be more involved in the programmes; for example, students will be encouraged to partake in the creation of the new curriculum. The objective is to lessen student reliance on being taught exactly what is going to be examined. The flexible curriculum is supposed to be dynamic and must incorporate direct and easy access to the faculty.

Face to face/"Virtual" education. Academic institutions today are in transition. There is an increasing shift towards the use of the Internet in courses, which is evident from the development of virtual universities. Online teaching provides the possibility to expand the scope and the content of the curriculum. The new model will be more interactive than the basic form of computer-assisted education. It will allow students to post comments to discuss areas of interest or concern on the World Wide Web. It may also include chat rooms, where all participants may log on to a course site and interact with each other in real time. The aim is to develop students into more active and creative learners.

A wide range of data can be placed on the Internet, including the theory of Descriptive Geometry, and the description of drawing techniques (freehand drawing, computer graphics-software, etc.). Face-to-face classrooms or lectures have to be used to convey general instructions and provide examples, and for projects in which students will have a chance to apply their acquired knowledge.

Multidisciplinary approach must be incorporated into undergraduate courses. Communication skills will be fostered by means of project work but will also be taught formally by means of assessed reports and presentations that will implement elements from other related areas of visual science. It will incorporate not only knowledge in technical freehand sketching and computer aided drafting in accordance with standards, but also the capability and the creativity to understand areas such as architectural graphics, technical illustration-graphs and charts, presentation graphics, artistic drawing, multimedia and similar elements [5]. This approach will provide an opportunity for students from different faculties, who deal with visual data, to learn together about principles of visual language in a course that will have an interdisciplinary approach. It can result in joint projects of students from different engineering disciplines, architecture, fine arts, agriculture, medicine, geography, chemistry and/or physics.

Collaboration is the key to enriching engineering education. Faced with greater competition from nontraditional providers in the industry, each university must continually reinvent itself and collaborate with industry to develop flexible solutions using IT [4].

Universities must maintain an enhanced environment that is in touch with the requirements of the real world. Universities must be in permanent collaboration and interaction with industry in order to assist students in developing the necessary skills needed to meet future employment requirements. There are three levels of possible collaboration, which are stated as follows:

1) Collaboration among students - team work;
2) Collaboration with other units from within the faculty or between faculties around the world; and/or
3) Collaboration with government and/or industry.

The Internet may be used as a medium for providing students with the instructions and requirements of the unit; including information on projects, basic concepts and theory, and the assessment structure. The main form of student learning will derive from working on the projects that will highlight the importance of teamwork. The projects may be modeled upon projects from other units that incorporate drawings, or real projects from industry. As practice, students can volunteer their services to different design offices to produce some drawings. This creates a demand to place the visual communication unit in the second year of undergraduate study, instead of where it is currently offered (the first semester in the first year of undergraduate study). In first year, students lack knowledge about the engineering profession and basic engineering concepts; therefore are less equipped to tackle real projects.

6 Conclusion

Globalisation made possible through the revolution of IT has resulted in a new breed of engineers with multidisciplinary abilities. This multidisciplinary approach forms the foundation for the basic outline of the future curriculum for the Visual Communication unit proposed. It will involve the use of a combination of the traditional classroom and the classroom in cyberspace.

- Lectures used primarily to convey general information though the teacher will continue to define course content and drive the course (teacher-manager);
- Student-centered learning approach via broad online subject matter, where students will be able to pursue their own interests;
- Face-to-face tutorials based on specialised real projects completed in teams;
- Unit placed in second year - requires some basic knowledge about the course; and
- Flexible curriculum open to students from a wide range of different faculties interested to learn to communicate visually (all branches of engineering, Architecture, Geography, Agriculture, Medicine, Physics, Chemistry, etc.)

The overall teaching philosophy must remain dynamic and ever changing.

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