Facilitating Learning of Engineering Graphics Instead of Learning CAD System.

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Abstract: The advancement of computers in both hardware and software has led to the replacement of hand-held instruments with CAD system in engineering graphics course. The syllabus of engineering graphics courses has also shifted more towards learning the CAD system. This paper provides an in-depth examination of engineering graphic course content and proposed a well-balanced course content between fundamentals of graphics and CAD. It also includes a brief overview of scheduling and course evaluation methodology.

Keywords: engineering graphics, CAD, facilitating learning, course content

1. Introduction

Graphics has been heralded as one of the cornerstone in engineering, as an effective medium of communication between engineers and other technical persons in engineering profession. Almost all engineering schools related in mechanical or chemical engineering discipline provide for a course in Engineering Graphics. This course used to be conducted in a classroom or laboratory equipped with drawing boards, T-square, set-squares and other hand-held instruments. The advancement of computers, hardware and software, has led to the replacement of hand-held instruments with computer-aided design, CAD, as a tool for facilitating learning.

A change in the drawing tools, from hand-held instruments to computers, has inadvertently led to a shift in course objective and students interest [1]. The syllabuses of engineering graphics courses have slightly diverted from its main objective of teaching students so that they can read and write the graphic language clearly using universally accepted symbols, conventions, standards and principles. Lately, it was found that more often the course content for engineering graphics courses tend to focus more on the need to learn the ropes of the software. Facilitators and demonstrators also tend to dwell on the CAD software instead of focusing on the fundamentals of graphic language. Thus, students tend to focus on learning the CAD software rather than graphics fundamentals. The challenge to facilitate engineering graphics is further compounded by the difficulty in scheduling an effective program.

The course content should be well balanced between fundamentals of graphics and computer-aided design. In the development of an engineering graphics course, it is necessary to consider this new engineering environment and formulate course objectives which will ensure that future engineers will be best prepared to efficiently use CAD tools to communicate their ideas and design solution [2].

This paper provides an in-depth examination of the course content and its implementation, scheduling, coursework and evaluation criteria to accommodate the utilization of CAD as a tool to facilitate learning.

2. Course Content

Dr Raul Herrera [1] in his paper acknowledge, "The usefulness of the CAD systems in the teaching-learning process and their utilization in the job market is unquestioned. What remains to be studied is how much and to what depth these systems should be taught, so that students attention stays focused on training their minds to improve their visualization skills and on applying graphical solutions to engineering problems."

The concerns of many professors and educators is the increasing number of engineering schools that are over emphasizing on learning the CAD system. A random survey was conducted by visiting numerous engineering colleges' website and browsing through their course outline for engineering graphics or similar courses offered. Among the various topics that can be categorized as CAD biased are listed in Table 1.

Table 1. Course outline biased towards CAD.

Topics
Introduction to Engineering Graphics & CAD
Command entry; Data entry; Draw Commands
Drawing Aids; Entity Selection
Construct; Modify
Display control; Layers; Linetype; Color
Text
Hatching
Dimensioning
2D Graphics
Surface Representation / Surface Modeling
3D Modeling
Solid Modeling / Parametric Modeling
Plotting and Printing

The same exercise was conducted to identify topics that are considered within the circle of engineering graphics fundamentals as shown in Table 2. Traditional topics such as sketching, pictorial, orthographic, sectional views and dimensioning are among the more commonly incorporated.

Table 2. Course outline of Engineering Graphics.

Topics
Introduction to Engineering Graphics
Sketching – Isometric; Oblique; Perspective
Pictorials Drawing
Multiview / Orthographic Projections
Auxiliary view
Details Drawings / Title Block
Sectional Views
Dimensioning
Threads & Fasteners
Gears & Cams
Assembly Drawings/ BOM/Balloons

At Universiti Teknologi Petronas, Malaysia, the approach adopted is to facilitate teaching-learning of engineering graphics course by designing the course to be well balanced between fundamentals of engineering graphics and incorporating computer-aided design as its tool (Refer Table 3). Engineering Graphics, EMB 2013 is a 3 credit hour course offered during the 2nd year of a five year bachelor of engineering program at Universiti Teknologi Petronas. Mechanical and chemical engineering students taking this course have already had an introductory course in computing, algebra and calculus. This course is offered 4 hours per week, to meet the minimum requirement set by the National Accreditation Board (LAN). The guideline stipulated by the board is that one credit hour is equivalent to an hour of lecture, or an hour and a half of tutorial, or two hour of practical laboratory work.

Accordingly, for engineering graphics, an hour of lecture is delivered on fundamentals and concept of engineering graphics. Another full hour is dedicated on demonstration with the CAD system adopted as a tool for completing classwork and homework assignments, while two solid hour is allotted for the lab-tutorial session.

Table 3. Fundamentals of Engineering Graphics balanced with learning CAD as a tool.

Sample Topics	Engineering Graphics	CAD tools
SKETCHING	-introduction and importance of engineering graphics -lines; linetypes and lettering -sketching techniques -sketching isometric view -sketching oblique view	- None
MULTIVIEW	-multiview; front; side; plan; -orthographic projection; view selection -geometric symbols -1st angle projections -3rd angle projections -layout and drawing placements -lines representation; object; hidden; center; construction -line precedence -border; title-blocks	-introduction to CAD -command entry; keyboard; menus; toolbars -data entry; coordinate system; absolute; incremental; polar -draw lines; arcs; circles; polygons; ellipse; text -linetypes; layers; colors -drawing aids; entity selection; -copy; offset; mirror; array -move; rotate; scale; trim;erase
SECTIONING	-purpose and concept of sectioning -section view basics -cutting plane -sectioning symbols -type of sections -conventional breaks -application of sections	-draw polyline & arrowheads -draw and label cutting planes -hatching style -hatching pattern -hatching scale -hatching angle manipulation -draw balloons
DIMENSIONING	-basics of dimension -parts of dimension -rules and guidelines -extension & dimension placements -grouping dimension -centerline and center marks -dimensioning symbols -dimensioning system	-draw linear dimension -draw aligned dimension -baseline and continuos -circular dimensions -leader lines -angular dimensioning -setting dimension styles; annotation; units ; precision -setting dimension format and justification

Lectures are conducted in the CAD laboratory so as to allow for continuity with the demonstration and lab-tutorial session. The number of students are limited by the number of workstations available. This is to ensure effective learning, where each student has a hands-on learning experience when utilizing the CAD to implement the fundamentals and concept learned the previous hour. Effectiveness of the laboratory session can be ensured by the availability of one or two demonstrators depending on the number of students in each session. This is especially so when the design of the CAD laboratory can be obstructive to student's view where those seated at the back can hardly focus details on the projected screen.

Each lecture session should start with fundamental concepts, engineering drawing principles, related conventions, symbols and abbreviations of that particular topic. As an example, a topic on sectioning should begin with section view basics, purpose of performing sections, cutting plane concepts and symbols, various hatching pattern, scale and its representations, types of sectioning, and various sectioning applications. Basically this session describes the *what* and *why* issues.

The demonstration session that follows immediately after the lecture session can clearly guide students the various commands, steps required, execution methodology, simple examples, case example and applications. This session demonstrates the *how* issues.

In the Engineering Workstation Laboratory used for teaching engineering graphics at UTP, various teaching aids are provided. LCD is used to present learning materials using electronic presentations. Transparencies are used to support with various materials, while the marker-board is used for further clarification, explanation and materials enhancement. Changing from one teaching tool to another can stimulate the student's attention and avoid boredom. Changing from one delivery mode to another will also require switching on and off the lighting system, which create changes in environment and stimulates students' attention. Through many years of experience, having the lights turned off for the whole lecture session, while using LCD or overhead projector, will definitely put some of the students to sleep.

The course starts with sketching techniques, after a short introduction and importance of engineering graphics. These include sketching in isometric and oblique. Subsequently, the basic concepts and fundamentals of orthographic projections are introduced together with CAD as a tool. Students are gradually introduced to details drawing, title block, text and numbering. Later, topics on sectioning, dimensioning, thread and fasteners, gears and cams, assembly drawings with balloons and bill of materials, and finally completed with working drawings.

In the future other than lecture and lab-tutorial session video and CD-ROM's presentation, invited professional speaker and field trip will also be incorporated to improve student's learning.

3. Scheduling

To ensure effective learning, blocking or continuos session is adopted as shown in Table 4. Students are able to apply the basic engineering concepts as soon as they learn them. This is further enhanced with an hour demonstration on its application on CAD system and a two-hour laboratory and tutorial session. Even though the continuos four-hour session is quite long, provision of refreshing breaks will allow for an optimum learning session.

Table 4. Blocking or Continuos Session.

Length of Session	One hour	One hour	Two hour		Two hour
Session Contents	Lecture / engineering concepts	Demonstration & application on CAD	Lab & Tutorial		Homework (lab) assignment

Table 5a. Scheduling for Engineering Graphics in Year 1999.

	8:00 am - 10:00 am		**8:00 pm - 10:00 pm**
Monday (Section 1)	Lecture & Demo.		Lab & Tutorial
Wednesday (Section 2)	Lecture & Demo.		Lab & Tutorial

Table 5b. Scheduling for Engineering Graphics in Year 2000.

	8:00 am – 10:00 am	**10:00 am - 12:00 pm**
Tuesday (Section 1)	Lecture & Demo.	Lab & Tutorial
Thursday (Section 2)	Lecture & Demo.	Lab & Tutorial

Initially it was thought that a split session of two hours, as shown in Table 5a, would allow students more time to grasp and absorb information learned during the two-hour lecture and demonstrations session. Instead, the tutors ended having to repeat learning materials presented in the earlier session since most students requires a relearning curve in the laboratory and tutorial session. Hence, from this year onwards the session for Engineering Graphics is block or continuos (Refer Table 5b), which is more effective. Positive response from students overweighs those complaints of session being too long. As mentioned earlier, short breaks were provided between session to refresh the students.

The materials selected for the lab-tutorial session should differ slightly from homework materials. While the exercise materials for lab-tutorial session is more focus towards what has been learned in the current lecture session, the exercises meant as homework should try to accommodate or incorporate as much as possible all materials learned the previous lectures. Utmost importance is that these exercises are training students on applying graphical solutions to engineering problems and improving their visualization skills.

4. Coursework and Evaluation.

Grades assigned in each undergraduate course are intended to reflect achievement relative to a defined level of competence. While most courses have a final examination to assess student achievement, in engineering graphics it is more feasible to conduct a continuos assessment. Student accumulates grades points based entirely on coursework.

Lab-tutorial session forms an important component of assessing student ability to focus and absorb learning materials while being guided and coerced by tutor. Homework assignment forms the other major component of coursework, training students to improve their visualization skills and applying graphical solutions to engineering problems. Quiz and mid-term assessment are used for assessing student's comprehension on the subject matter. Instead of a final examination, which is very cumbersome when using CAD as a tool, a final semester project is a more reliable assessment of student's ability. The final semester project should be as close to an actual working drawing used in industry complete with detail drawings, assemblies and parts lists. The project selected should require students to apply most of the course contents learned for that semester.

To implement a final examination for engineering graphic course will introduce numerous complications and controversies. Since the capacity for most CAD laboratories are design for between 30– 40 students, an examination for any larger number of students will require some scheduling. Quarantine will have to be implemented if the same set of problems is meant for all the students. Alternatively, multiple set of exam problems of "supposedly" similar standard and difficulties have to be prepared. This approach almost always attract complains from students that the exam questions are of different difficulty levels.

To have examination using hand-held instruments is perfectly easy. Using CAD laboratory for conducting a final can sometime turn into a complete nightmare. Imagine after painstaking preparation and maintaining the computers, to still have a student facing computer breakdown during finals. Even though technically all the computers are the same, students are well aware of those particular stations that crawls, with corrupted files, missing menus, printing misconfigurations and various other hardware and system problems.

5. Conclusion

Development of a well balanced engineering graphics course content is critical in ensuring future engineers will be prepared for the new engineering environment. The course content should be balanced between fundamentals of engineering graphics and computer-aided design. Time allocated and depth of coverage in these two focus areas will ensure that the course objectives to improve students' visualization skills and to efficiently use CAD tools to communicate their ideas and design solution can be achieved. Implementing continuos session has been found to enhance effective learning as conducted at UTP. A split session between lecture, demonstration and lab-tutorial has been found to be less effective and requiring a higher learning curve. The nature of engineering graphics course objectives with CAD as a tool calls for a different method of assessment. Instead of exam orientated it was found that a project-orientated evaluation is more applicable. Continuos assessment of students' lab-tutorials, homework assignments, quizzes, mid-term assessment and project is a more accurate assessment instead of a final examination. Complications and controversies that arise with having a final using CAD are thus avoided.

6. References

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