

Active Learning Strategies in Engineering Design and Computer Aided Design Education

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Abstract

Teaching the design process has involved numerous strategies which have been evolving over the past decades due to innovations in technology. New and fashionable educational methodologies, e-learning and wireless networked laptop technology are only the latest in a series of developments available to the computer aided design (CAD) instructor. The Internet as a tool for acquiring information from global sources has also proved invaluable to engineering students worldwide as an aid to research in many areas of their study, including design. Engineering departments, for their part, have responded by preparing courses that develop the skills of their students in using these technologies and methodologies.

The focus of this paper deals with the active learning and new technologies in teaching students about CAD and design. Students acquire a clear understanding of geometric construction using 2-D CAD, the fundamentals of orthographic projections using both freehand sketching and CAD software, dimensioning techniques, and isometric sketching. Students also learn 3-D solid modeling using solid primitives and Boolean operations to create composite solids. In addition, they use coordinate systems and various viewing transformations as well as develop 3-D spatial visualization skills and the ability to read and prepare engineering drawings in addition to undertaking an CAD project. Students with little or no prior skills in visualization will have developed and honed their abilities in using it as an effective design tool.

Furthermore, this course facilitates the student in two key educational areas which are evaluated in this paper. Firstly, the implementation of strategies to facilitate the transition of students from passive to active learning. Secondly, the role of educational methodologies in promoting independent and group centered learning skills as opposed to their prior experience of highly dependent learning.

Keywords: CAD, Laptop, Active Learning, Integration.

Introduction

Course development is an ongoing and ceaseless process, with re-training of instructors being necessary and frequent in order to keep pace with advances and in order for these instructors (be they early or late adoptors) to comfortably appreciate and implement such technology [1]. Additionally, some observers feel that the entire educational system, not only in Gulf countries, but in the Arab world as a whole is in desperate need of an overhaul [2]. Understanding the needs of company management is also important at the educational level in engineering departments, in spite of graduates often becoming part of a national workforce where employment is guaranteed. Employees need graduates ready to work rather than having to be re-trained on variations of a given technology.

The College of Engineering at UAE University, during the early period after its foundation (1980-1992), followed a classical curricular pattern similar to that dominant in the region. Realizing that tomorrow's engineer has to face the challenges of modern technology and the demands of modern society, the university administration initiated a major effort to modernize the engineering curriculum, to parallel the most recent international trends, particularly the curricula promoted in the USA as well as in many other countries.

The methodology of the current work has utilized techniques for the evaluation of learning outcomes of students in line with ABET (Accreditation Board for Engineering and Technology) requirements, as well as the use of student questionnaires to evaluate student response to the course.

The computer and other information technologies revolutionized the way engineering is carried out many years ago. They are, however, only now beginning to revolutionize the way engineering subjects are taught [3]. Modernization of teaching methodology for the Engineering Design and Graphics course followed the trend adopted in the freshman year curriculum. Five courses were developed in 1996 and five more were implemented the following year. In the teaching of all these courses, the conventional lecture method in which the engineering instructor recites and demonstrates information and concepts was reduced to a minimum. In the newly developed approach, the engineering instructor is to assume the role of "manager of learning". In this format, the student is lead to a series of activities that will enable him/her to master fundamental concepts. Nowhere is the approach more evident than in the Engineering Design and Graphics course.

Overview of Active Learning

Teaching is fundamentally about creating the pedagogical, social, and ethical conditions under which students agree to take charge of their own learning both individually and collectively.

Therefore, the goal of an active learning strategy is to teach in a way that engages students in learning. As such teaching consists of getting students involved in the active construction of knowledge. Thus, the aim is not only to transmit information, but also to transform students

from passive recipients of other people's knowledge into active constructors of their own and others' knowledge.

To implement active learning as a viable strategy, the instructor must impart four key objectives in every classroom session. These are activity, reflection, collaboration and passion. The class time should be managed in such a way as it is not only a fifty minute lecture in the traditional sense, but rather that the class time is broken into distinct blocks of learning. For example, this could begin with a 10-20 minute introductory mini-lecture, followed by a 15-20 minute small group activity, followed by 5-10 minutes of group feedback and finishing off with concluding remarks and learning outcomes from the instructor [4].

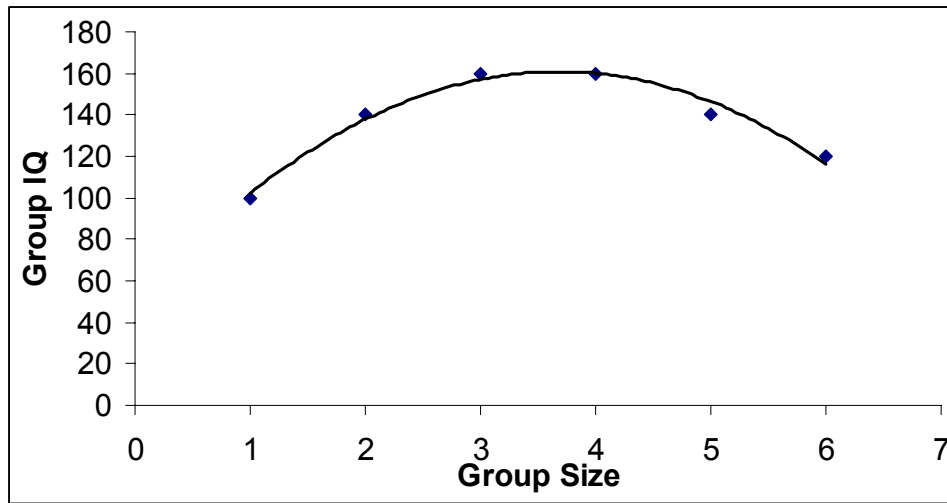


Figure 1: Importance of Collaboration in the Learning Process [5].

There are numerous active learning methods and approaches that are facilitated by new technologies and their application often varies from one discipline to another, often within the same faculty. These various methods are valuable in assisting the development and restructuring of courses. Some of the are outlined here.

Engaged Learning deals with increased and focussed student interaction, as well as collaboration amongst instructors and students. The focus is on the instructor as a facilitator and an emphasis is placed on technology as a tool for learning.

Project-Based Learning deals with real-world issues in engineering and requires a sustained period of cooperative investigation and collaboration amongst a student group in the completion of a project or task.

Cooperative learning (CL) is a generic term for various small group interactive instructional procedures. Students work together on academic tasks in small groups to help themselves and their teammates learn together. CL involves people working in teams to accomplish a common goal. It consists of various key concepts. The most essential of these are positive interdependence, where all members must cooperate to complete the assigned task, individual and group accountability, where each member is accountable for the complete final outcome, face-to-face promotive interaction, teamwork skills and group processing. Optimization of group size is also critical for effective CL (Figure 1).

Problem-based Learning is a philosophy of teaching and learning through which students work together to solve problems of priority to them and to their community through input from experts, research, and the collaborative testing of potential solutions. Structured problem-solving can be used in conjunction with several other cooperative learning structures.

Effective Team Learning

Though team learning is a vitally important skill in today's engineering company, adopting active learning strategies to facilitate both implementation and assessment of this type of learning is very difficult in this region. The greatest problem faced by instructors as well as the studious participant is the "Hitchhikers and couch potatoes" phenomenon [6], the former being an individual in the group who is carried with the group by making a minimal, insufficient contribution and the latter is simply too lazy to make a contribution often relying on the committed student to do the work for him. Though this is not solely limited to the Gulf educational zone, with numerous problems surfacing in the west, it seems that cultural influences in the region affect the group dynamic in a more diverse way than in the western model.

Theory X, Theory Y and Active Learning in the Gulf

The value of active learning must be considered within an appropriate context when dealing with students in a Gulf setting. A major issue here is to understand that a positive learning experience can only occur when diversity is appreciated. From an instructors perspective, development of

curricula must reflect an understanding of different teaching styles. In terms of students, consideration of cultural and gender issues is of paramount importance in the region.

One way to look at this is to consider motivational theory and organizational behavior. Theory X and theory Y is a good example. Theory X assumes that people inherently dislike doing any work and that people must be coerced into working to achieve set objectives. Thus, people prefer to be directed. In education, this relates very closely to mindset of the Gulf archetypal student, where students in the early stages of tertiary education require or expect a "spoon-feeding" approach to learning, with little or no critical thinking and no effort beyond the limits of what has been stated by the instructor.

In contrast, theory Y assumes that people view work as being a natural part of life, accepting as well as seeking responsibility, progression, promotion [7]. This relates well to the archetypal western student who naturally goes beyond the bounds of the classroom dialectic to further explore, research and investigate the subject matter. Traditionally, as a result of these archetypal student types, the theory X model has over time resulted in the "stick" approach, where, in order to get valuable work out of students, they are given very specific tasks each of which are closely related to the marking regime, or GPA. In contrast, students following the theory Y model are taught with a bias towards the "carrot" approach, given broader outlines to learning objectives. Thus Theory X is a much more dependent learning style than Theory Y. The goal of an active learning methodology in the Gulf, therefore, is to encourage a shift from Theory X dependent learning guided by the "stick" to Theory Y independent learning encouraged by the "carrot".

Another aspect of motivational theory which is interesting was outlined by F. W. Taylor [8] who stated that people are inherently motivated by money and will only work according to financial benefits to be gained from the work. Again, by analogy, it can clearly be seen that the archetypal Gulf student is motivated by GPA. This is evident from both behavior and dialogue. Gulf students will almost always ask the point value of any piece before making an attempt at it. Often a student will not turn in a homework assignment if he knows that it was assigned for gaining an understanding of the material, rather than for marks. What such a student fails to ultimately realize, is that through gaining greater understanding of the material, his marks will naturally increase when graded assignments are due.

Class Size

"The greatest single challenge to SMET pedagogical reform remains the problem of whether and how large classes can be infused with more active and interactive learning methods." [9]

Class size has become an ever increasing problem in the UAE. In engineering, student numbers have increased so dramatically over the past decade that attempts at keeping up with changes required to team based learning, class room dynamic, individual skills testing such as oral presentations and so on, is proving difficult.

Intensive and Reflective Learning

One more recent consideration amongst those involved in active learning strategy is the concept of intensive and reflective learning, where, rather than having an evenly spread curriculum for a course, say over a sixteen week period, instead, blocks of teaching are introduced, followed by periods of enhanced learning through research, reflection and reporting. This method, though valuable in the west, can prove problematic in the Gulf, particularly at the (early) undergraduate levels where students still remain in need of a cultural shift towards independent learning. New technologies have also enhanced this thinking as the use of email, internet, intranet, video walls etc have allowed interaction between student and instructor during the blocks of reflection.

Copying, Plagiarism and Cheating

Although consistency with other international universities (USA in particular) is advisable for a coherent policy on plagiarism, cultural variation must also be taken into account. For example, student nature in the UAE and middle east in general, has a much greater spirit of cooperation than their contemporaries in the west. Although this, in itself is a noble attribute, such students will happily provide their work to a fellow student, without considering themselves as unethical or copying his original work. In addition, the student copying his work will regard his colleague as merely helpful. In contrast, students in the west are more competitive and consequently more possessive of their own work. Thus, the nature of plagiarizing is more confined to copying textual and IT sources (Internet) rather than fellow students.

Engineering Design, CAD and Use of New Technologies

The Engineering Graphics course deals with geometric constructions using 2-D CAD, fundamentals of orthographic projections using both freehand sketching and CAD software, dimensioning techniques, scaling of CAD drawings, isometric sketching, 3-D solid modeling using solid primitives and Boolean operations to create composite solids, coordinate system and viewing transformations.

The Design Project course covers an introduction to the engineering design process, where students work in teams on a project provided by a faculty member. Faculty members serve as project advisor. A final group oral presentation is made to a jury panel composed of faculty members and a final written group report is submitted.

It is important for the instructors teaching these courses at the freshman level, to have an appreciation for the discipline of interest to the student. At UAE University, College of Engineering, this is by no means a small task, as, at this level, students remain unsure as to which discipline is of interest to them (Figure 2).

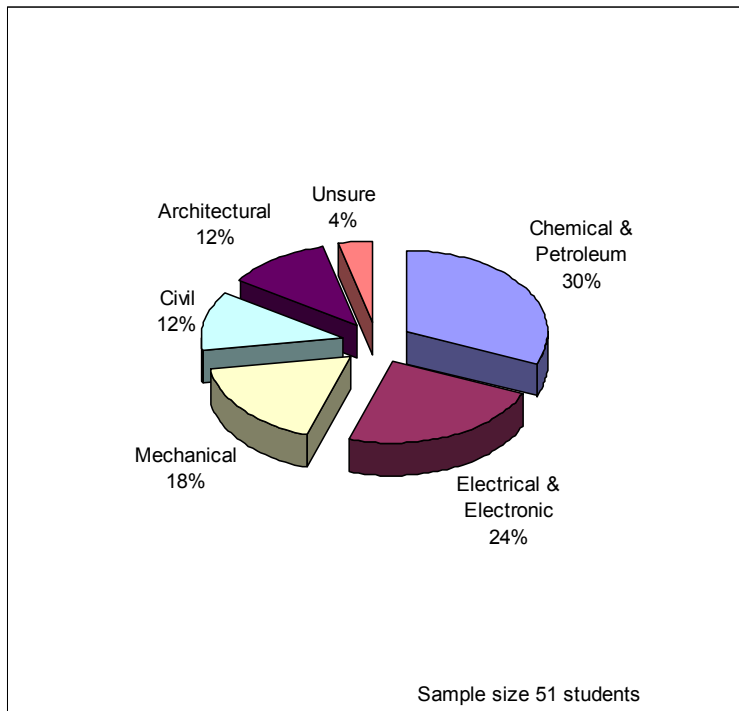


Figure 2: Initial thoughts of specialization discipline of students entering the College of Engineering [10].

In-class course activities were developed which utilize both NetOp and Blackboard. This allows for greater student interaction during lecture time, electronic distribution and submission of assignments and quizzes and electronic grading, thus eradicating all paper activities and maximizing wireless laptop applications.

In a practical sense, the instructor circulates around the classroom and can also remotely monitor the students. For example, during assignment work, instructors circulate or remotely monitor the students, giving hints, and checking for understanding (Figure 3). This is helpful in providing instruction for leadership, decision-making, communication, and conflict management.



Figure 3: Student working in a wireless environment on a CAD assignment.

Five types of software are used in this course. Internet Explorer is used by the instructor and the students to search and browse the internet for information about their design project and to access the course materials posted on the UAEU web. AutoCAD is used by the students to complete examples and assignments. NetOP is used by the instructor to monitor students and remotely control individual student machines (when required). Blackboard is used by the instructor to post and manage course materials on the web. On line quizzes are provided to assess the individual student performance. The software is also used by students for accessing course material and using available communication tools (e.g., chatting, e-mail, forums ...etc.). "ViewLet" software is used by the instructor to develop animations that show the use of AutoCAD. Table 1 outlines how these new technologies have effected change in terms of classroom management.

Table 1: Implementation of New Technologies into the Learning Process.

New Delivery Method	Old Delivery Method
Viewlets, NetOP and Blackboard to broadcast PowerPoint presentations, Word documents, clarify the main concepts of the discussed AutoCAD examples as well as the design projects' background.	Whiteboard used to discuss the example assignments and design project background.
AutoCAD examples and Viewlets have some interactive parts that can be used by the students to discover and simulate different scenarios of the problems.	Whiteboard used to discuss the details of the example problems and project background.
Instructors use NetOP to monitor the activities of individual or group of students during the hands-on AutoCAD sessions. Instructors also (in some cases) circulate around the students to answer questions and discuss problem related issues.	Instructors circulate around students to answer questions.
Instructors post and manage the essential course materials on the web using Blackboard.	Instructors distribute handouts.
Blackboard is used for the collection of student files for the solved assignments, quizzes in AutoCAD.	Instructors distribute hardcopies of the assignments and students are required to hand-in the hardcopy of the solved assignments.
Remote office hours and chat capabilities built into Blackboard are used as a medium for student-student and student-instructor communications.	Instructors specify office hours at which they have to be available in their offices.
On-line and traditional quizzes used to assess the students' performance and provide students with instant feedback.	Hardcopy quizzes are used to assess the students' performance.
"Viewlets" (animations) showing the use of AutoCAD are used in the class and are available online for the students' access.	Real-time use of AutoCAD is displayed for the students.

Consequently, course development can select a number of e-learning tools such as web delivery, multimedia development, specialized software as well as other discipline specific software and techniques. Figure 4 illustrates the generic model for course development at UAE University, College of Engineering with a view to integrating the traditional development processes with technology based subjects and technology demanding delivery.

Future Work

It is envisaged that ultimately all of the current course materials will be transformed into a digital format and posted on the web using Blackboard. This will require further animations which may be developed using ViewLet technology or similar, to describe the use of CAD and design tools. Furthermore, work towards a fully integrated on-line quizzing regime is being developed as well as new interactive presentations for the example assignments.

Conclusion

The paper has dealt with three key aspects to the tuition of Design and CAD.

First, the importance of examining and understanding active learning and how this can make a positive contribution to students in the Gulf.

Secondly, the use of new technology in facilitating such learning through the use of NetOP substituting the whiteboard, "Viewlets" for online display of the use of relevant software, remote office hours concurrently available with traditional office hours, communication through e-mails and chatting being encouraged, student-student collaboration to promote communication skills and student interaction with interactive course materials. All these technologies and more can help to promote independent learning.

Finally, the paper examined the Design and Engineering Graphics courses and their latest developments within the dialectic of active learning and new technology.

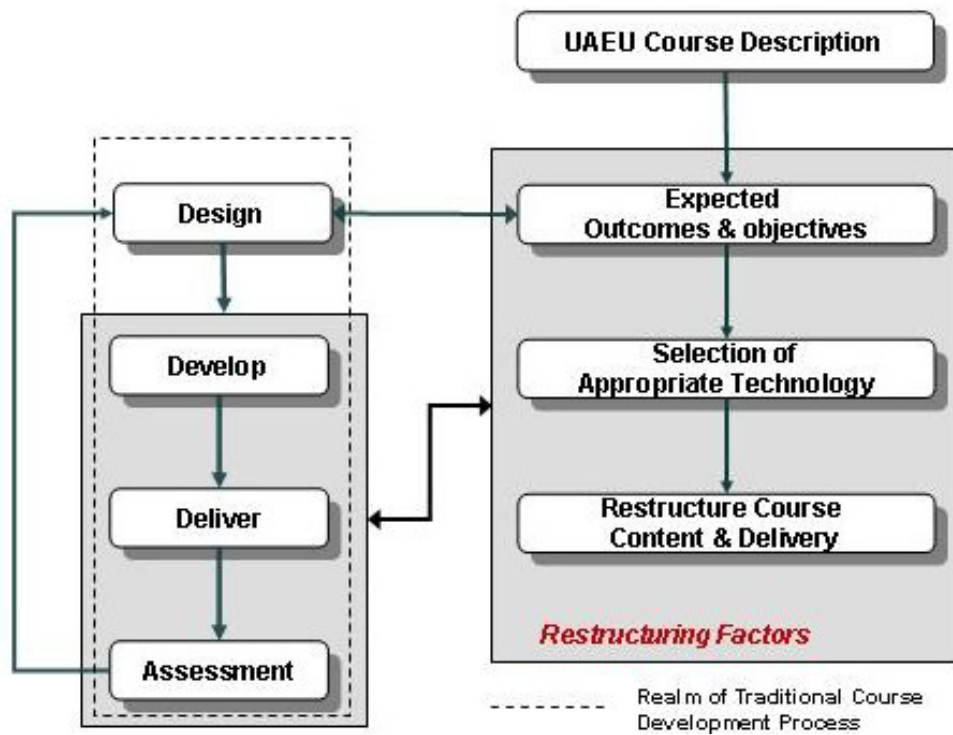


Figure 4: Course Development Process at UAE University, College of Engineering.

References

1. McKenzie, J., Scoring High with New Information Technologies, From Now On: The Educational Journal, Vol. 8, No. 7, 1999.
2. Al-Maeena, K., , “Where is the Quality in Arab Education?”, Arab News, Jeddah, Saudi Arabia, (17th June) 1997.
3. Byron-Pipes and R., Wilson, J., A Multimedia Model for Undergraduate Education, Technology in Society, Vol. 18, No. 3, pp 387 – 401, 1996.
4. Roland Christensen, C., Garvin, D. A., and Sweet, A., Education For Judgment: The Artistry Of Discussion Leadership, Cambridge, MA: Harvard Business School, 1991.
5. Perkins, D., King Arthur's Round Table: How Collaborative Conversations Create Smart Organizations, Wiley, New York, 2003.
6. Oakley, B., It Takes Two to Tango: How 'Good' Students Enable Problematic Behavior in Teams, Journal of Student Centered Learning, Vol. 1, Issue 1, pp. 19 – 27, Fall 2002.
7. Heil, G., Bennis, W. and Stephens, D.C., Douglas McGregor, Revisited: Managing the Human Side of the Enterprise, John Wiley and Sons, New York, 2000.
8. Wood, J.C., Wood, M.C., F. W. Taylor: Critical Evaluations in Business and Management (Critical Evaluations in Business and Management), Routledge, London, 2002.
9. Seymour, E., Tracking The Processes Of Change In US Undergraduate Education In Science, Mathematics, Engineering, And Technology, Science Education Journal, pp. 79 - 105, 2001.
10. Randeree, K., The Internet as a Tool for Effectively Understanding the Engineering Profession, Proc. 6th Saudi Technical Conference, King Fahd University of Petroleum and Minerals (KFUPM), Dhahran, Kingdom of Saudi Arabia, 2002.