Oppenheimer Award Winner

Computer Methods in EDG Education

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ABSTRACT

This paper presents several computer related techniques that encourage EDG students to develop knowledge at levels 4 and 5 of Bloom's taxonomy. These knowledge levels are associated with generalized problem solving in undergraduates and research capabilities in graduate students. The approach presented is intended to extend the educational process in contrast to the development of training skills at knowledge levels 2 and 3 that are often the sole basis for EDG instruction.

In the decade since "The Seven Principles for Good Practice in Undergraduate Education" appeared in the American Association of Higher Education Bulletin, it has served as an important guidepost in defining and evaluating "good teaching." One of these seven principles is to encourage active learning. It was suggested that this be accomplished through team projects, challenging discussions, independent study and other similar means. While most educators use some or all of these methods in their classes, it should be remembered that these suggestions predated the widespread use of modern techniques, such as computer driven presentations and the World Wide Web (WWW).

Today's EDG education can be enhanced by such things as adding an animation to a normally static computer drive lecture, or using the WWW to actively explore topics such as the optical illusions of M.C. Escher and the camera obscura art of the 17th century Dutch artist Vermeer. This paper presents several methods and topics similar to those mentioned above. It is intended to support the concept that there are many facets of an EDG education and that, while fundamentals and required skills must remain at the center of our curriculum, the student can benefit greatly by discovering directly how those principles relate to a broader scope than normally presented.

Introduction

Bloom's (1984) taxonomy quantifies a learner's various knowledge levels by assigning numerical values to identifiable stages . Although these levels are presented in slightly differing formats by various authorities the following will serve as a guide for this paper.

Level 1 – **Information Processing** The learner can discuss and give definitions but has a low level of comprehension.

Level 2 – **Knowledge** The learner has processed information and relationships and demonstrates a degree of comprehension.

Level 3 – **Knowledge Skill** The learner can skillfully make use of the knowledge in new contexts and can teach this knowledge to others.

Level 4 – **Problem Solution** The learner can solve complex problems by integrating new knowledge skills with pre-existing knowledge skills.

Level 5 – **New Knowledge** The learner can validate and test research hypotheses and communicate understanding at an expert level.

Undergraduate programs primarily deal with Level 3 and Level 4 knowledge. They stress a student's ability to demonstrate Level 3 knowledge on a broad range of topics and Level 4 knowledge in specific areas related to their chosen field. Graduate programs require students to further exhibit Level 4 knowledge and to develop Level 5 knowledge in their areas of interest. Words such as apply, model, analyze, infer and design are often used to test for these levels of knowledge. These same words are used to define critical thinking – "...actively conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered..." (Richard, 1998).

To obtain these knowledge levels and critical thinking skills requires a learning environment that emphasizes the importance of involving the student in their own education while de-emphasizing training and the "sage-on-the-stage" atmosphere. This does not mean that training has no place in a university setting but that broad principle based topics and active learning methods should take precedence over limited and very specific training experiences. For example, in EDG programs it is fairly common to spend more class/lab time training students to use a specific CAD system than in discussing general principles and allowing students to explore related topics or analyze real world applications.

Problem exploration is one of the key components in becoming an active learner as defined by A. Chickering and Z. Gamson (1987) in their *American Association of Higher Education Bulletin* article "The Seven Principles for Good Practice in Undergraduate Education." This article points out that educators should encourage active learning through team projects, in-depth discussions, independent study and self-guided tours through selected topics. If "The Seven Principles..." had been written today, rather than a decade ago, it would have surely pointed to the Internet and World Wide Web (WWW) as an ideal tool for fostering and supporting active learning.

The WWW is an extraordinary tool for assisting students with broad based or specific problem exploration, as well as a resource for instructors wishing to enhance their classroom presentations. The materials described in the following paragraphs are free or inexpensive materials found through the WWW that I have found valuable in trying to foster an active learning style in my classes, as well as, making my presentations more effective. I have broken the WWW sites into four categories as follows:

- Visual Thinking
- Graphical Exploration
- Animations
- Viewers

Visual Thinking

Since we live in a word oriented society (reading, writing, speaking), it is useful to provide students with entertaining and thought provoking visual materials that enhance their visual and graphical skills. Learning to think visually can be enhanced by studying illusions such as those found at ***http://www.illusionworks.com***. The interactive demonstrations are very interesting and the discussions surrounding the many illusions provide a highway for further investigation.

M.C. Escher is well known for his impossible figures. An intriguing Escher puzzle can be found at ***http://www.thameshudson.co.uk***. After arriving at this home page, select Multimedia and then download the Interactive Puzzle (*Figure 1*). This puzzle involves the student in interactively forming an impossible triangle from the five pieces provided. The solution forces the student to think "outside of the box."

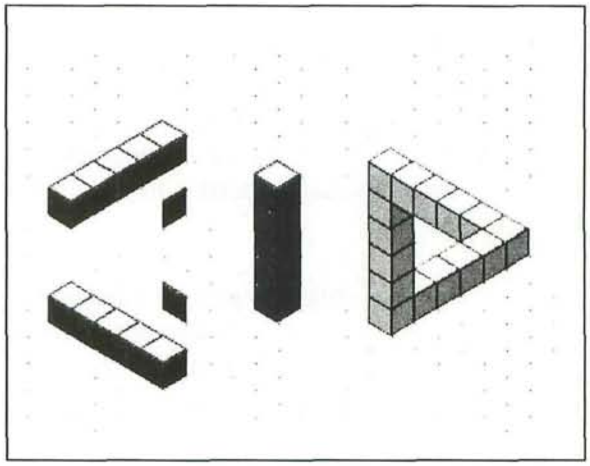

Figure 1 - Escher puzzle.

Graphical Exploration

Graphical explorations can be used to add interest to classroom topics. For instance, ***http://www.grand-illusions.com/vermeer3.htm*** contain a discussion and illustrations of how Professor Philip Steadman performed a reverse perspective analysis on Vermeer's paintings and determined that he had indeed used a *camera obscura* in their production (*Figure 2*). This had long been suspected, but Professor Steadman's work provided a solid technical basis for the findings.

The use of graphics to display mathematical data is often used to assist a student in understanding fundamental mathematical relationships. The West Point Civil Engineering web page uses graphical methods in a very effective manner on several project-related problems. One of these, ***http://ftp.usma.edu/cme/civilsoft.htm***, allows the student to change several variables in the design of a trebuchet and to graphically check whether it hits a target and to determine how the changes affect the loft height and range of the projectile (*Figure 3*).

Animations

Animations often provide insight into the operation of a machine or other device that cannot be matched by an essay or static pictures. The ***http://www.stirlingengine.com*** site contains an animation of a Stirling engine along with a discussion of how it operates (*Figure 4*). The animation is provided by Koichi Hirata and is very effective

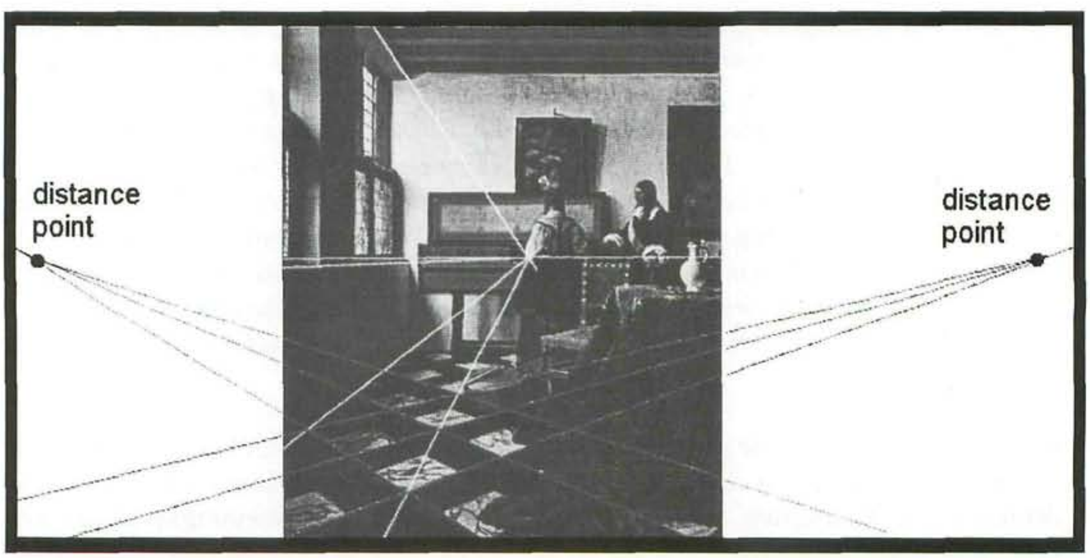

***Figure 2** - Professor Steadman's reverse perspective analysis.*

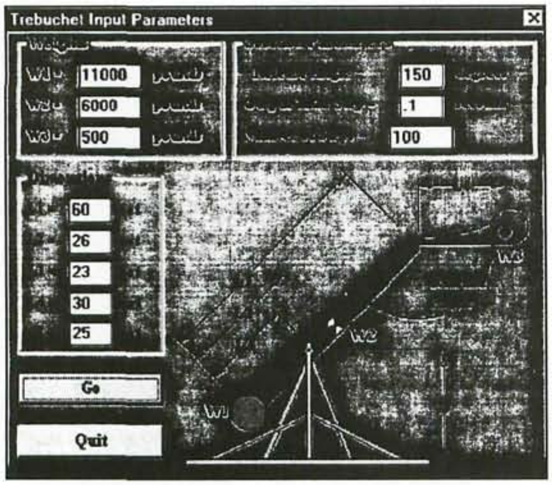

Figure 3 - Trebuchet projectile analysis.

in demonstrating the working principles of the Stirling cycle. The site also contains several intriguing demonstrations and applications for small Stirling engines.

At ***http://www.sover.net/~manx/necker.html*** Mark Newbold provides an animation that demonstrates the Necker cube problem better than any static picture I have encountered (*Figure 5*). The animation forces the viewer's eyes to select and reselect the surface to be used for the front of a cube. I have modified this example slightly for use in my class but your students will readily see the Necker effect when viewing the given animation.

To produce your own animations a trial version (30-day) of the shareware tool Animagic can be downloaded from ***http://www.rtlsoft.com/animagic/index.html***. This application automatically combines your static graphic images to create an animation. For instance, you could provide an image of a ball at three different heights (top, middle, ground) and Animagic would create an animation time line display that rapidly shows the ball at each successive height. By placing this time line in a loop the ball appears to continuously bounce.

Viewers

Several free viewers are available that allow anyone to view a graphic file without the need to have the application package that created the graphic. The ACIS Viewer 4.0 is a good example and can be found at ***http://www.spatial.com*** (*Figure 6*). This viewer can be used with any .sat formatted file. It provides very powerful viewing capabilities including a unique continuous rotation capability that may replace true animation in some applications.

Being able to enlarge a portion of a presentation often makes it much easier for a student to see exactly how a pick was made or to readily identify the value for a dimension. The Loupe (freeware for Win3.1 and shareware Win95-NT) can be downloaded from ***http://www.execpc.com/~sbd/Loupe.html.*** It automatically displays an enlarged/reduced picture of the area surrounding the cursor and is often handy when trying to read a B or C sized drawing on a CAD monitor or when demonstrating the selection of small icons on a classroom monitor. Windows 98 already contains a similar application known as Magnifier, but for a previous operating system the Loupe works almost as well.

A university education should provide the student with the critical thinking and exploration skills that will make them a life long learner and a valuable citizen. The WWW has become an immense playing field upon which to hone these required skills and it

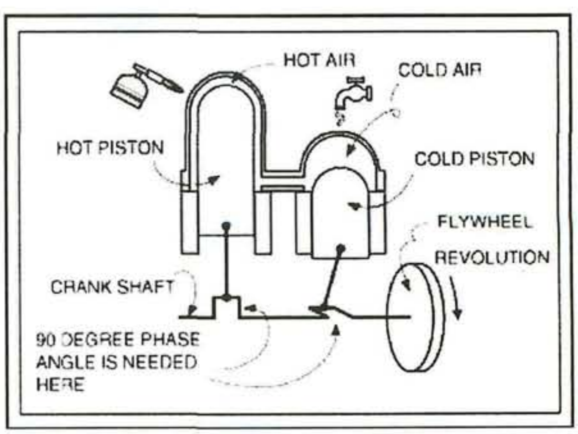

Figure 4 *- Stirling engine cycle.*

should be utilized by both the faculty and the students to improve the educational process. Properly using the WWW on group projects can help us to teach in a way that enhances critical thinking skills through exploration and interaction.

References

Bloom, B. S. & Krathwohle, D. R. (1984). *Taxonomy of educational objectives. Handbook I: The cognitive domain*. New York: Addison-Wesley Publishing Co.

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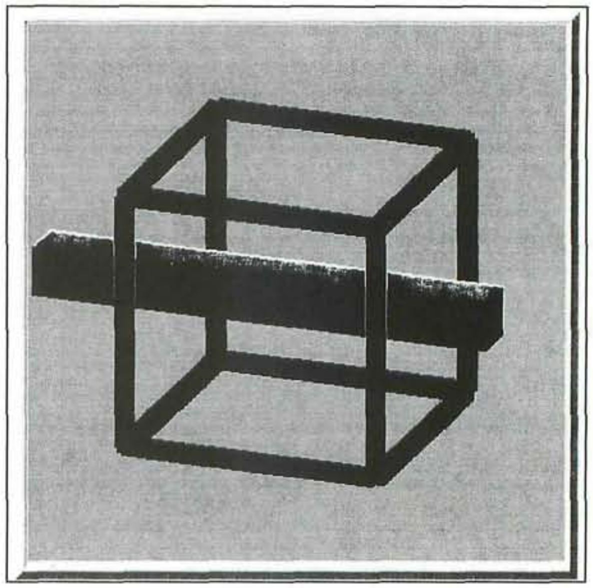

Figure 5 *- Necker cube.*

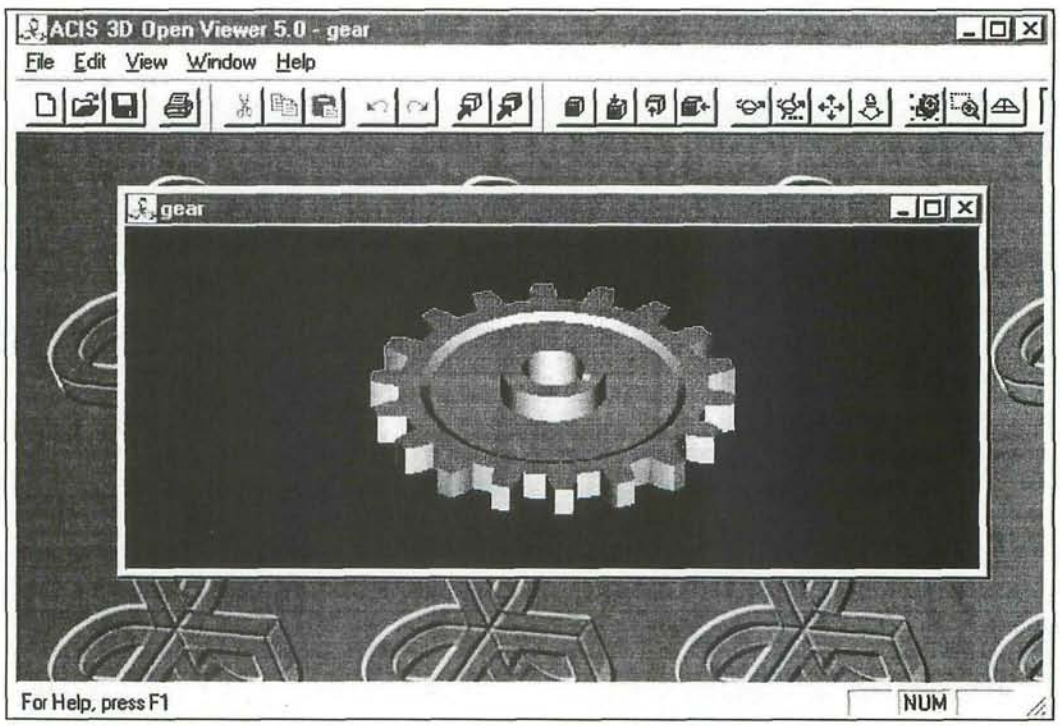

Figure 6 *- The ACIS viewer.*