Volume 63 • Number 3

Creativity Development in a Freshman Level Engineering Graphics Course – An Application

Patrick E. Connolly
Purdue University
and
Mary A. Sadowski
Arizona State University-East

ABSTRACT

The ability to solve problems is a skill that is highly valued and sought after by employers in many areas of industry. Graduates of engineering and engineering technology programs that come into the workforce with the training to provide solutions to problems are, therefore, in high demand. To provide students with this ability to look at issues in novel, inventive, and ingenious ways, educators must include creativity-enhancing, inventiveness-developing exercises for the students into their curricula on a regular basis.

Much research has been done on creativity development and creative problem solving applications, and many solutions have been proposed for educational situations, including directed design projects, junior- and senior-level design groups, team applications, semester projects, and 'open-ended' problem sets. Unfortunately, most of these high-end solutions are focused on upper division or senior-level students. This paper proposes a simple approach for including exercises into the freshman level classroom, to help first and second semester students approach problems and problem solving in novel and inventive ways. By working through these opportunities, the students' creative abilities begin to be developed, providing a stepping stone to more involved creativity developing exercises and projects, and resulting in early, confidence-building success in the problem solving area. Examples of typical exercises will be discussed, as well as student feedback to the exercises.

Introduction

Creativity is an essential component of design. Many times, the graphics related issues the professional must deal with require solutions that are new and different. Without creativity, there cannot be any novelty or newness or ingenuity in the solutions to problems. Harrisberger states, "The crux of the design process is creating a satisfactory solution to a need." (Harrisberger, 1982). It is the uniqueness of the potential solution that makes creative problem solving so essential to product success. "Creativity has a connotation of originality, which may be characterized by novelty, difference, ingeniousness, unexpectedness, or inventiveness" (Goetz, 1989).

A significant amount of research has been done that highlights the fact that creative ability or the talent of creativity is one that can be learned and developed (Harrisberger, 1982) (Vernon, 1989) (Feldhusan, 1995) (O'Neil Jr., Abedi & Spielberger, 1994). One of the more notable contributors in this field is Betty Edwards. Her book, "*Drawing on the Right Side of the Brain*" has become somewhat of a classic for educators and students alike. Edwards ascribes to the theory that direct perception, a different kind of "seeing" is an integral part of thinking–hence the creative process (Edwards, 1989). In her books, Edwards explores methods for developing the language of drawing which allows us to record our thoughts and ideas using a visual language which is similar to our written language. She sees many parallels between learning a drawing language and reading. In both, it is necessary to learn and integrate all the components and prerequisite skills before they become automatic. She recommends that a basic set of drawing skills including a variety of integrated visual-perceptions strategies could be taught to children at an early age so these skills can become part of their toolbox for solving problems by the means of visual strategies.

Teaching Creativity

The teaching of creativity is dependent on many factors and learning environments, but several things that aid in the process are fairly easy to incorporate into the classroom. Some of the key items center around the nature of problems the students need to solve, and the amount and types of constraints that are applied to the problem and allowable solution methods (Amabile & Tighe,1993) (Amabile, 1983). Basically stated, the more open-ended the problem, and the fewer constraints applied, the more creative the solutions tend to be.

Another aspect of creative development that cannot be discounted is that practicing creativity helps one to be more creative. Just as physical exercise develops physical fitness, creative exercise develops creative fitness. Michalko states that specific creativity exercises can ". . . train you how to get ideas" (Michalko, 1991). Many researchers and educators believe that educational systems put too much emphasis on facts, details, memory, and predetermined answers, forcing a dominance in linear thinking (Edwards, 1986) (Feldhusan, 1995) (Hermann, 1989). This develops the logical, analytical and verbal abilities but can result in a lack of development in the conceptual and creative abilities. As a consequence, the intuitive, conceptual and imagery skills are not as well developed. When we ask engineers and technologists to devise a creative solution to a problem, it is important that they have a well-developed set of skills to help them search out and find alternative or creative solutions.

In the Department of Computer Graphics at Purdue University, we expect our students to develop and apply a variety of creative skills by the time they graduate. In the junior and senior level courses, a great deal of time is spent helping the students strengthen their talents and exhibit the results of their creative abilities.

It is a logical assumption that if we can get the students thinking along creative lines earlier in the curriculum structure, they will be better prepared for the expected creative rigor in the upper division classes, and better prepared to be creative in their future careers.

The Application

The creativity development exercises that we chose to apply in this class were small problems known as "brainteasers." This type of activity was chosen because of the level of the class, class size, and nature of the activity, and is based on the concept that solving problems in innovative ways develops creative thinking.

The class consisted of ninety-six students, primarily first or second semester freshmen. At this level, students in our program have had minimal demands placed on them requiring the use of their creative ability. We thought giving the students short brainteasers as exercises would not be as overwhelming to them as other types of creativity enhancing projects might be.

Another factor in the choice of activity type was the time commitment involved. Our desire was to insert creativity exercises in the class without disrupting the normal flow of the class or taking away from the necessary topical content to be covered. Also, with ninety-six students, it was necessary to find a method that would not place an overly large burden on faculty and graders with regards to time and effort.

The assignments were given to the students as ten-minute problems at the conclusion of lecture, once per week. In this way, it was also an effective method of checking attendance at lectures. Answers to the problems were given before the next creativity problem was given.

Examples of the creativity problems that were given to the students are shown in the following pages. They were drawn from a number of sources, including creativity texts and articles, the Internet, and such diverse locations as newspapers and elementary school assignments. Michalko emphasizes the importance of having both linear exercises (those that allow the manipulation of information in ways that generate new ideas) and intuitive exercises (show how to find ideas via imagination and intuition) (Michalko, 1991).

Problem Sets

The first exercise that was presented to them is shown in *Figure 1*. The instructions for this linear technique problem were to count the number of squares in the picture. There were many students that quickly jumped at

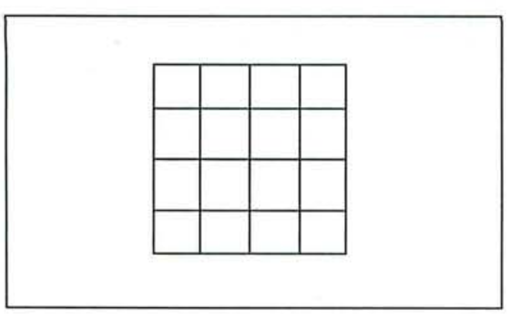


Figure 1 *- Squares puzzle.*

the obvious solution of 16, and did not take the time to analyze the data more carefully. Others tried various ways to break the squares down by size mathematically to account for all possible permutations of squares. The goal was to have the students move from the obvious on-the-surface solution, and look at the problem from different perspectives. The purpose is to overcome what Gillespie identifies one of the major perceptual mental blocks to creativity, "the inability to overcome a preconceived viewpoint or to visualize an object as having more than one function" (Gillespie, 1972).

The second assignment (*Figure 2*) was more intuitive in nature. It required students to develop the popular phrase or saying from the clue given. Overall, the results were good, although several of the puzzles were solved by only a few of the students. An interesting problem that arose from this problem was the difficulty that students who spoke English as a second language had in solving it. This resulted in the elimination of other word problems that might be language biased.

The third problem is a very famous one (*Figure 3*). The students were asked to draw lines through each of the dots using only four straight lines, without going back over any lines, and without lifting their pencil off the paper. As an additional challenge, the students were asked to solve the problem using only three straight lines, if they could. Given the famous nature of the problem, it was not surprising that several students knew the answer. Many students, however, were not able to solve the problem, which requires one to discard the misconception that one cannot draw outside the physical limit of the dots themselves.

The fourth exercise, shown in *Figure 4*, required the students to develop the pattern that was causing letters to be placed either inside or outside the circle. Students developed several workable patterns to solve the

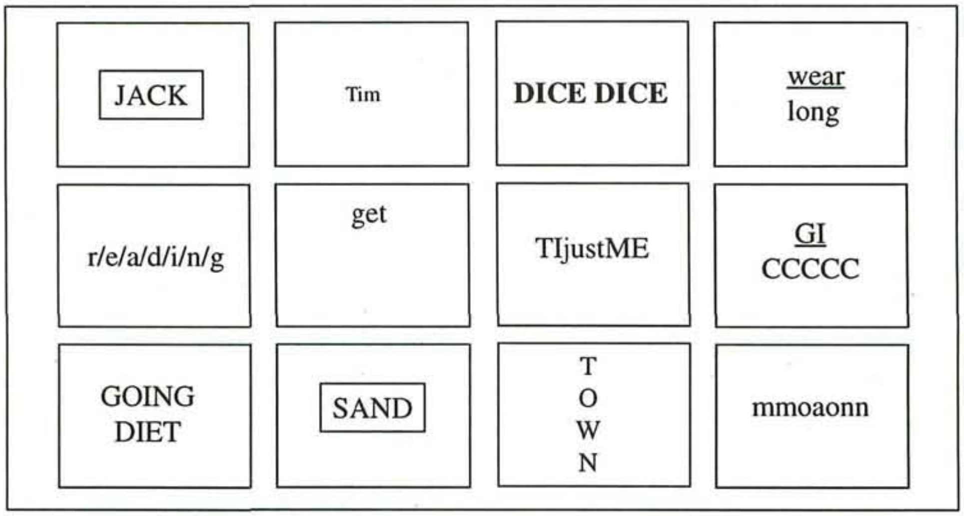


***Figure 2** - Hidden meanings puzzle.*

problem. The results from this problem caused the authors to change their paradigm regarding how to measure 'success' and 'failure' for the problems, as several of the students' answers were also 'correct' (solved the problem), even though their answers were different from the supposed correct answer.

For the fifth exercise, another famous problem was chosen. This is known as the Greek Cross (*Figure 5*), and requires three-dimensional thinking to solve it. The requirement is to move only two coins to create a row and a column that total six coins each. Many students solved this quickly, possibly because they had by this time been exposed to many 3D CAD assignments and were used to working in three dimensions.

Many students solved the sixth exercise (*Figure 6*) also, although not all in the manner expected. The problem requires making the equation correct without adding, taking away, or re-arranging the matches. By this point in the semester, the students seemed very adept at looking at the problems from various ways, analyzing problem constraints, and developing unique answers.

Problem seven revisited similar issues as problem one, except with triangles, instead of squares (*Figure 7*). Interestingly, it appeared that many students found it more difficult to do than the first problem. Perhaps the addition of diagonal lines adds an additional level of complexity to the problem that did not exist with simple squares.

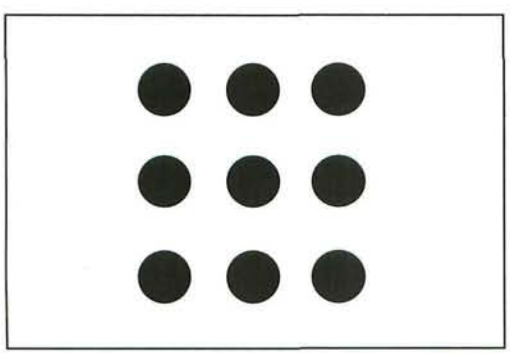


***Figure 3** - Nine dot puzzle.*

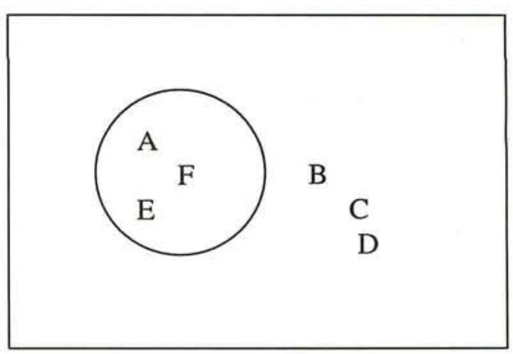


***Figure 4** - Pattern puzzle.*

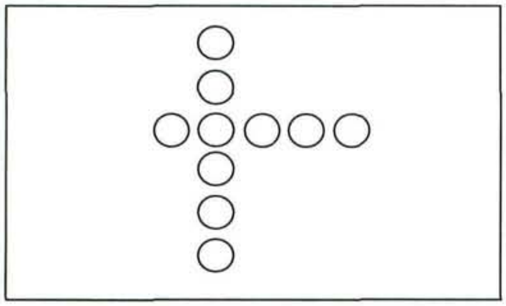


Figure 5 - Greek cross.

XI + I = X

Figure 6 - Equation puzzle.

Another puzzle is the picture shown in *Figure 8*. The goal is to make the fish swim in the opposite direction by moving only three toothpicks and the dime. Students found this very challenging and generated many sketches before solving the problem. This problem is difficult enough that it should be given towards the end of the semester, and with the allowance of additional time to solve.

Results and Suggestions

Several observations were made during the course of the semester regarding the effectiveness of the exercises and corrections needed to make them more effective in the future.

The students' comments regarding the exercises were very positive, with the great majority requesting that the problems continue to be used. Without a method of testing creativity skills before and after the semester, it is not possible to quantitatively measure if there was any increase in creativity/problem solving skills due to the exercises. However, based on the experts' research into problem sets of this sort and their effect, and observations made during the semester, it appears that students have expanded their ability to think more effectively to solve problems.

Several suggestions that may lead to improved application in future semesters include avoiding language-based issues, not limiting students to one 'right' answer where possible, and allowing for teams or groups to work on more difficult problems. Another application that would be interesting would be to develop short CAD brainteasers, actual CAD based exercises that require creative solutions. This would not only help develop creativity, but would provide more hands-on time for the students. It would not be possible to do this in most lecture situations, however, so its application would be limited.
The students seemed to enjoy visual graphic problems more than word-based problems. Graphical or mathematical problems also

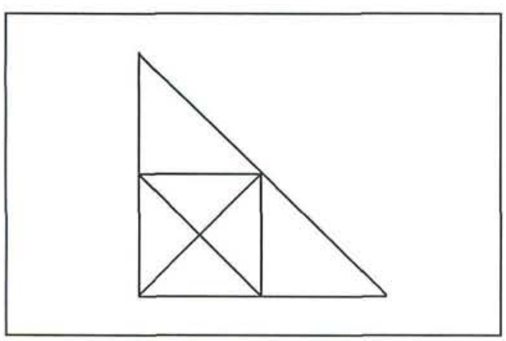


Figure 7 - Triangle puzzle.

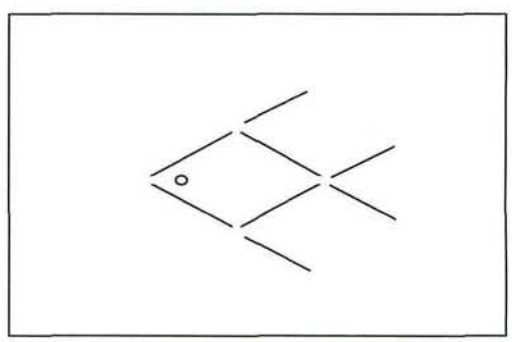


Figure 8 - Fish puzzle.

avoid any ESL issues, as mentioned previously. As students gained experience and confidence in their problem solving skills, many tried to find 'correct' answers to a given problem that were different than the one the instructor had. It is important that other correct answers also be accepted as possible solutions.

Eventually students should be expected to graduate with some experience in working in groups or on teams. One possible early exposure to this would be to allow groups of two or three to solve the brainteaser problems. This approach would be an effective introduction into major group or team projects that might be included in upper division classes.

Conclusion

The importance placed on creative ability by today's employers is an aspect of student development that we as educators cannot overlook. It has been proven that incorporating challenging, open-ended problems into course assignments can help students expand their creative capabilities. For the most part, team-oriented design projects in the junior and senior-level classes are used to meet this need. However, by using simple "brainteaser" exercises, faculty can introduce students to problems that will help develop their creative problem-solving skills earlier in the curriculum, even at the freshman level. These brainteaser assignments can be simple and short, thereby fitting almost any course schedule with a minimum of negative impact. Students respond well to the exercises, and will be more prepared to be innovative in upper-division design classes and in industry by the experience gained in attempting to solve the problems. There are many reference works, both in print and Internet-based, that are a resource for exercises of this nature. They can be very broad in scope, ranging from simple picture puzzles to highly complex mathematical equations or word problems. Gradually increasing the difficulty of the problems, and the level of creativity expected of the students, will increase their creative output and abilities.

Solutions to Problems

Figure 1.

30 squares

Figure 2.

Row 1

Jack in the box
Tiny Tim
Paradise
Long underwear

Row 2

Reading between the lines
Get up
Just in Time
GI over seas

Row 3

Going on a diet
Sandbox
Downtown
Man in the moon

Figure 3.

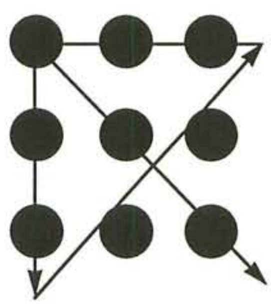


Figure 4.

Letters with only straight line segments inside the circle, letters with any curve line segments outside the circle.

Figure 5.

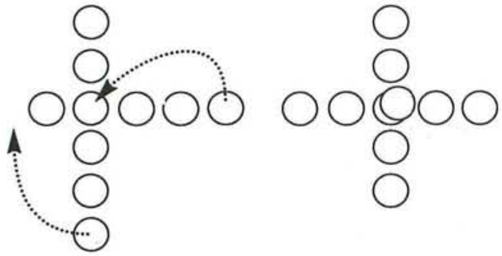


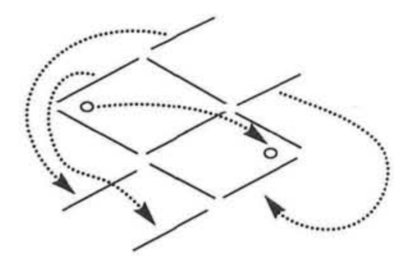
Figure 6.

Turn the equation upside down (rotate it 180 degrees).

Figure 7.

13 triangles

Figure 8.



References

Amabile, T.M. and Tighe, E. (1993). *Questions of creativity*. Creativity, 7-27. New York: John Brockman Associates, Inc.

Amabile, T.M. (1983). *The social psychology of creativity*. New York: Springer-Verlag.

Edwards, B. (1986). *Drawing on the artist within*. New York: Simon and Schuster, Inc.

Edwards, B. (1989). *Drawing on the right side of the brain*. Los Angeles: Jeremy P. Tarcher, Inc.

Feldhusan, J. F. (1995). Creativity: Aknowledge base, metacognitive skills, and personality factors. *Journal of Creative Behavior*, 29 (4), pp. 255-268.

Gillespie, R.J. (1972). Roadblocks to creativity. In A. M. Biondi (Ed.), The creative process. New York: D. O. K. Publishers.

Goetz, E.M. (1989). The teaching of creativity to preschool children. *Handbook of creativity*, 411-428. New York: Plenum Publishing Corp.

Harrisberger, L. (1982). *Engineersmanship-: the doing of engineering design*, (2nd Edition). Belmont, CA: Wadsworth, Inc.

Hermann, N. (1989). *The creative brain*. Lake Lure, NC: Brain Books.

Michalko, M. (1991). *Thinkertoys*. Berkeley, CA: Ten Speed Press.

O'Neil Jr., H. O., Abedi, J. & Spielberger, C. D. (1994). The measurement and teaching of creativity. In H. F. O'Neil Jr. (Ed.) & M. Drillings (Ed.), *Motivation: Theory and research*, 245-263. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Vernon, P.E. (1989). The nature-nurture problem in creativity. *Handbook of creativity*, 93-110. New York: Plenum Publishing Corp.