

# Implementing Innovative Visual Aids in Engineering Education

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## Abstract

Educators classify student-learning styles into four groups: kinesthetic, tactile, visual and audio. Recent surveys reveal that the visual method is predominant in among my engineering students. This concept is not new to experienced engineering faculty, who normally use graphs, blueprints, maps and other graphics as teaching tools. Course designers can obtain useful visual aids from a variety of electronic media. For example, many visual resources are readily available on the web. Other resources can be tailor-made by the faculty to meet specific course needs using highly visual software. For example, Mathcad and Labview may be used to create animations that simulate time-dependent phenomena.

Visual aids can also be used as interesting virtual tools so that the students can break the “four walls” barriers in the classroom environment. Implementation of these visual aids in my courses simplifies understanding of difficult concepts. Their use also enhances understanding, while creating a more enjoyable learning experience. Implementation of innovative visual tools in engineering courses is illustrated by comparing examples of conventional didactic methods with enhanced models. The three examples include the introduction of innovative visual enhancements to a term project statement, a linear regression problem and the use of a multimedia computer presentation to communicate the need for engineers to perform environmental assessments prior to execution of a project.

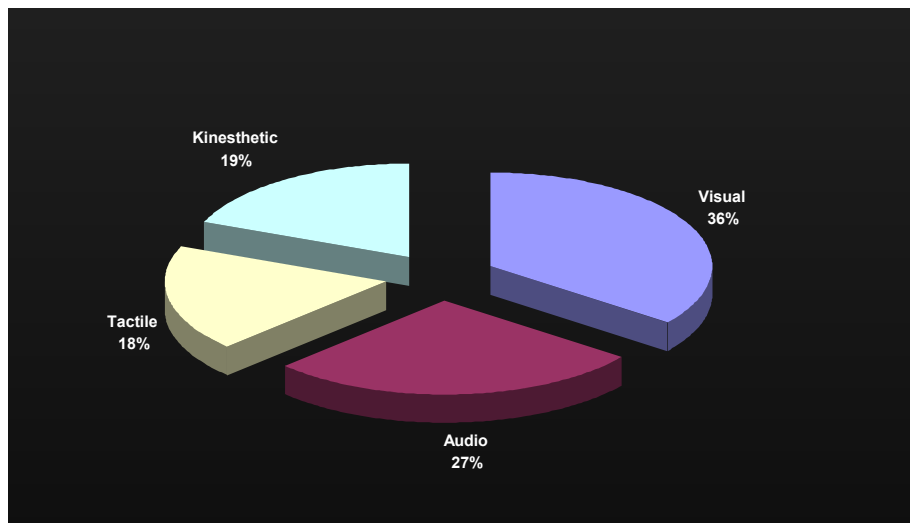
## Introduction

Education specialists categorize learning styles into four styles: audio, visual, tactile and kinesthetic. Table 1 describes the main characteristics of each learning style. A recent survey of the students in my Environmental Science class (33 engineering and environmental science sophomores) shows that on the average the students in this class prefer the visual and audio styles as illustrated in Figure 1. Figure 2 shows that that by far the majority of the students in this class prefer the visual style. These trends appear to be common in the engineering profession. It is not surprising to see seasoned engineers take full advantage of visual aids to communicate design concepts. The engineering faculty normally uses the same approach by enhancing his classroom experience with a variety of visual aids such as blueprints, maps, charts and various types of plots.

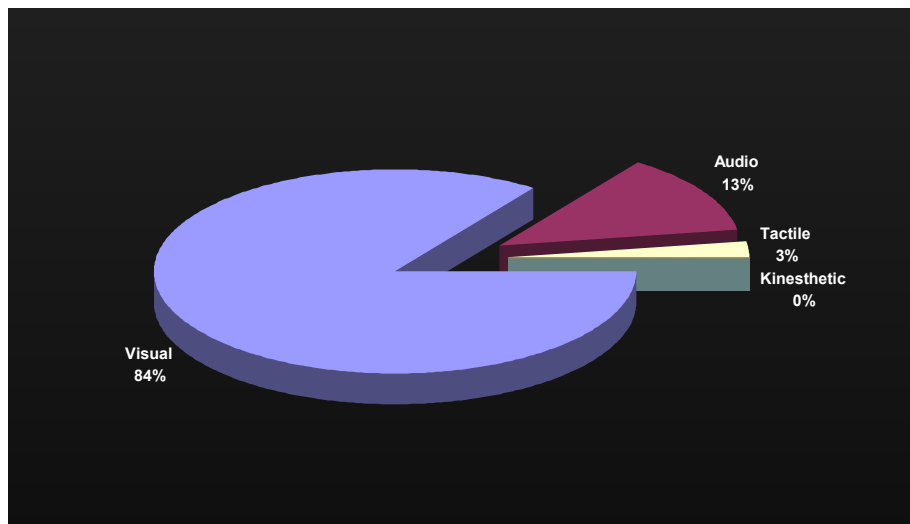
**Table 1. The Four Learning Styles**

<b>Learning Style</b>	<b>Examples</b>
Audio	Hearing: talking it out, reading out loud.
Kinesthetic	Moving: taking a walk, riding and bike, exercising.

Tactile	Performing labs, experiments, projects.
Visual	Reading text, diagrams, visual aids, notes.



**Figure 1. Learning Styles of Average Student in CE/ES 256, Fall, 2000**



**Figure 2. Preferred Learning Style in CE/ES 256, Fall, 2000**

The main goal of this publication is to share some of the novel visual resources that I have found useful during my teaching experience at NMSU. Most of these resources are readily available through the Internet. Other resources can be tailored to the students' needs using the visual graphics available through modern programming tools such as Mathcad and Labview. The lecturer can then share the visual aid library via the web or through the use of computer projectors in the modern classroom.

**Example 1. Use of Electronic Multimedia to Enhance Understanding of a Term Project.**

One of the most difficult tasks faced by educators is to keep the students' interest on the course goals and objectives after lecture hours. The students' understanding of individual course objectives is often fused and strengthened by one or more term projects. Instructors using traditional means depend on handouts, textbooks, and other printed material. Complementary materials, which can be inserted in problem statements, are easily available on the web. Maximum benefit from these materials is obtained when the project statement is placed on the web. These complementary materials easily expand the students' horizons and allow them to be participants, rather than spectators in the solution of the term project problems.

Web resources tend to be visual and auditory in nature. Figure 3 shows the introductory statement of a conventional term project in my Introduction to Environmental Science Class. A wide variety of concepts, ranging from geography to ecology is presented in this single paragraph.

The Paraná River is a major river that separates Brazil from Paraguay in South America. This river is a tributary to the La Plata River. The Paraná has been harnessed to generate electricity using the largest hydroelectric power plant in the world (the Itaipu Hydroelectric Reservoir). This river also supports a diverse variety of flora and fauna. A carnivorous species of red-bellied piranha (*Serrasalmus nattereri*), an endangered, man-eating species, is presently found in the river. This animal constitutes the main tourist attraction in the area. Ciudad del Este, a major community along the banks of the Paraná River discharges raw sewage into a tributary to this river ...

**Figure 3. Conventional Introductory Statement**

Students in the class often proceed to solve the numerical part of the term project problem without a thorough understanding of the global aspects of the problem. Figure 4 shows virtually the same text as the introduction to the term project in Figure 3. However, Figure 4 also shows the addition of several web-based visual links. Since all materials given in my class are now posted on Web-CT (the students in my class do not receive paper handouts), the students are free to access the original text and supplementary visual aids available through the links.

The [Paraná River](#) is a major river that separates [Brazil](#) from [Paraguay](#) in South America. This river is a tributary to the La Plata River. The Paraná has been harnessed to generate electricity using the largest hydroelectric power plant in the world (the [Itaipu Hydroelectric Reservoir](#)). This river also supports a diverse variety of flora and fauna. A carnivorous species of red-bellied piranha ([Serrasalmus nattereri](#)) an endangered man-eating species, is presently found in the river. This animal constitutes the main [tourist attraction](#) in the area. [Ciudad del Este](#), a major community along the banks of the Paraná River discharges raw sewage into a tributary to this river ...



[Green Sites](#)  
[Encyclopedia Online](#)  
[Greatest Places.org](#)



to this river ...



**Figure 4. Multimedia Introductory Statement**

The links on the enhanced problem statement allow the students to complement the basic text statement with important scientific and engineering issues. Most complementary material is highly visual in the form of relevant maps, photos, and even a virtual video of the assessment site. These resources were obtained from readily available web sites, such as travel organizations, the Encyclopedia Britannica Online, and the Vancouver Aquarium.

**Example 2. A Visual Example to Illustrate the Use of Linear Regression.**

Linear regression is a fundamental statistical tool used in both science and engineering. Traditional approaches require that the student knows how to apply the equations necessary to obtain the slope and intercept of a set of experimental (i.e., measured) data. The student is then asked to predict the slope and intercept of experimental x-y data and make predictions about the expected y values under various x conditions. I quote below a traditional example from a recent introductory engineering textbook:

“Plot a least squares fit curve (sic) through the following data, which represent average daily oil production, in barrels, for a single oil well for each of 12 consecutive months: 70, 64, 65, 60, 68, 58, 54, 58, 48, 49, 53.”

The student is likely to get the best-fit equation for this not very motivating exercise if he is careful to apply the proper procedure. However, since he has not appropriated the significance of the problem and its potential use in his career he sees no need to perform this work, other than to get a good grade.

I introduce this important statistical tool in a different fashion. First the students are shown a digitized version of the Tacoma Narrows bridge collapse (see Figure 5). This spectacular movie helps the student visualize how the deck of a bridge is swayed by wind. I have developed a Labview program that emulates (at least in principle) the effect of wind speed on measured deck deflections of a virtual suspended bridge, as seen by pressing the middle icon in Figure 5. The virtual controls and displays are shown on the classroom screen and a student is asked to adjust the wind velocity in the “wind tunnel.” The rest of the class then observes and records the reported deck positions. The class is given the task of providing guidelines to the highway department as to when to close down the bridge to traffic due to wind-induced swaying (they assume that the traffic can flow if the deflection is less than 0.5 ft). The students compute the linear regression coefficients that best fit their experimentally determined

data of deflection vs. wind speed. Solving the outcome equation they then determine the wind speed that would force the highway department to close down the bridge.

[Tacoma Narrows Movie](#)

[The Virtual Bridge  
Experiment](#)

[A Whale of a Problem  
Movie](#)

**Figure 5. Visual Tools Used in Examples 2 and 3**

It is logical advance, taking advantage of this example, to teach the concept of extrapolation. Using the linear regression equation, the students can then estimate the wind velocity required to make the bridge collapse. They are told that structural engineers predict that this catastrophic event will occur if the deflection exceeds 1.1 ft. After consensus is reached in the classroom, the student driving the controls is allowed to increase the wind speed to hurricane-strength levels. The students observe that the bridge appears to be out of control at about 80 mph. They are particularly fond of the “destructive” experiment when the bridge collapses as indicated by the red alarm conditions. The concept of extrapolation is communicated in a more personal fashion by allowing the students to compare their predicted values against actual observations.

### **Example 3. A Whale of an Environmental Problem.**

Environmental engineering faculty cannot overemphasize the need for all engineering students to evaluate the impact of their professional activities upon human well-being and the environment. Traditionally I have given examples to my students on engineering blunders leading to environmental disasters. It is no mystery, for instance, that well-intentioned chemical and mechanical engineers, who have forgotten this basic principle, have made two consecutive blunders regarding fuel additives. The first one introduced tetraethyl lead into gasoline that greatly improved octane power in internal combustion engines. Obviously such chemical has been banned in most developed countries after considerable environmental damage to air, water and land resources. The full extent on the intellectual development of children as a result of chronic lead poisoning remains unknown. More recently MTBE, was introduced in gasoline as the cure to our air pollution problems. This chemical was expected to increase fuel combustion efficiency. What engineers failed to consider was that this anthropogenic substance is not biodegradable. Present gasoline spills problems, which (prior to the MTBE addition epoch) degraded by natural means, are now expected to last for centuries.

I have found no better way the need for engineers to consider the environmental impact of their professional practice than through the message communicated by the multimedia show titled “A Whale of a Problem.” This digitized movie is played in the classroom, where civil and geological engineering students observe how one of their colleagues carries out an explosive environmental blunder. The concept is clearly communicated through this audiovisual aid within a few minutes. There seems to be a lot of truth in the old Chinese saying, “A picture is worth a thousand words.” The reader can access and enjoy every bit and piece of this movie by pressing the right link in Figure 5.

### **Conclusions**

Many engineering students prefer the visual learning method. This method seems to be complemented by audio and, to a lower extent, kinesthetic and tactile means. The modern classroom is equipped with electronic equipment that can be used to enhance the visual and audio learning experiences. Web-based courses are particularly suited to present complementary visual materials to the students. Many of these resources are readily available on the web. The professor can create additional materials that meet the students' needs. Interest in my courses has increased considerably as a result of the use of some of these visual aids. I also anticipate that this motivating environment improves the opportunities for the students to learn the course material and to expand their horizons beyond the classroom's four walls.

### **Acknowledgements**

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