

# A Comparison of Different Formats for Presenting Example Problems in Basic Engineering Web-Based Learning Modules

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**Abstract:** The purpose of this experiment was to compare three different formats for presenting example problems within Basic Engineering Web-Based learning modules. After seeing a lecture over the shear flow concept on-line, students in a Basic Engineering Class viewed example problems covering this topic in either a video, static text/graphic, or animation format. Students then completed a number of outcome measures. High ability students scored higher on a quiz covering the materials and rated the materials as less motivating than their low ability peers. However, there were no significant objective or subjective outcome differences as a function of presentation format, nor did ability and experimental condition interact. A number of possible explanations for these findings are discussed.

## Introduction

A great deal of time, money, and effort have gone into the development of learning technologies for Engineering Education over the years, and the pace has increased exponentially in the last decade due to the World Wide Web. Unfortunately, a substantial number of these technology-based learning innovations are integrated without any thought given to design issues, and, most importantly, without any thought to systematic evaluation of the impact of these technologies (Tergan, 1997). This is particularly unfortunate because, without

this type of feedback on new techniques and innovations, the most effective practices are not emphasized, and those that are ineffective remain. In response to this basic problem, some large organizations and agencies have identified evaluation and assessment as a fundamental hallmark of effective education. This is dramatically illustrated by the 2000 ABET criteria for engineering education ([www.abet.org](http://www.abet.org)), which emphasize the importance of a recursive method of course and curriculum evaluation, a process that will surely lead to more effective practices.

This same criticism has been aimed at all types of educational hypermedia. There have been surprisingly few examinations of the efficacy of hypermedia learning systems. In particular, few studies have systematically examined factors that effect the usefulness of these tools (Landauer, 1995; Dillon & Gabbard, 1998). Research that has been conducted has mostly failed to find that hypermedia instructional systems are significantly more effective than traditional instruction. In a now classic review of thirty studies published in the *Review of Educational Research*, Dillon and Gabbard (1998) conclude, "The majority of experimental findings to date indicate no significant comprehension difference using hypermedia or paper" (p. 326). They also note that, given the popularity of this technique, it's quite surprising that they could only find thirty controlled experiments of hypermedia that made use of objective outcomes. Further, they suggest that the lack of supporting evidence for the efficacy of hypermedia is most likely partly due to flaws in experimental design. This sentiment is also echoed by Tergan (Tergan, 1997) in a similarly comprehensive assessment of the existing literature, "...because of inherent shortcomings in design and research the potential of hypertext/hypermedia for enhancing learning may have been underestimated." Four years after the publication of the Dillon and Gabbard review, the picture appears to have changed little (Dillon, 2002).

One of the first issue that needs to be addressed, is the degree to which enriched multimedia should be added to facilitate instruction. This is particularly important, given practical issues with web based instruction, since such enrichments often require a good deal of development time and can also be problematic in terms of download time required. On the other hand, such enrichment has the potential to significantly facilitate learning, by providing the learner with information via multiple modalities (e.g., auditory and visual) (Mayer, 1997). This fundamental balance between the use of basic vs. resource rich presentations, is an important balancing act in Web design for learning (Hall, 2001; Hall, Watkins & Eller, in press).

Richard Mayer and colleagues, developed a theory of multimedia learning, which pose two basic principles: the modality and contiguity principle (Mayer, 1997). The modality principle contends that multimedia materials should utilize different perceptual modalities, so that, for example, pictorial information should be presented via auditory speech rather than written text, since the pictures and text both utilize the visual channel. The contiguity principle poses that multimedia presented simultaneously in time or space are more effective than when presented in sequence. A series of controlled laboratory experiments with children supported these principles (Mayer, 1997; Moreno & Mayer, 1999; Mayer, Heiser & Lonn, 2001). However, in recent years, research with so called "pedagogical agents", which are computerized characters that appear on the student's screen to help guide the learning process, have begun to pose some challenges for the modality principle. Despite the fact that these agents would appear to create redundancy for the visual channel, when they appear on a screen with visual information, they still have been found to facilitate learning (Atkinson, 2002).

The present research is related to this series of studies in that, first, it consists of a controlled examination of different types of learning factors, in computerized learning. Second, different types of multimedia modalities are examined: video in the form of a lecture, which would utilize both audio and visual channels; static text and graphics, which included two types of visual information, in a static format; and animations, which also included graphics and text, but the graphics were presented in the form of animations. However, this research extends the above studies in a number of ways as well. First, the material involves relatively complex basic engineering concepts and the subjects are engineering students at a technologically oriented university. Second, the dynamic animations are used to present core visually oriented concepts in three dimensions, rather than relatively simple illustrations, or an animated character. There is evidence that one of the primary areas in which educational hypermedia can be effective, is for displaying complex spatial concepts (Dillon & Gabbard, 1998). A third difference between this and previous research is that ability was considered, and, in fact there is evidence that the single most important factor in determining performance with

instructional multimedia is ability (Lanza & Roselli, 1991; Dillon & Gabbard, 1998; Dillon, 2002).

## Method

### Participants

One hundred and one students in an Engineering Statics class at the University of Missouri-Rolla participated in this experiment. They completed the experiment during their regular class time, as a class activity.

### Materials

Study materials consisted of a ten minute video taped lecture on shear flow, which consisted of a description of theory followed by a sample problem. This was followed by the presentation of two more sample problems in one of three formats: a) Video: a video taped lecture of the same professor presenting two sample problems; b) Text: A static text presentation of these same two example problems including some graphics; or c) An animation of the two example problems, including 3-dimensional dynamic illustrations of the spatial concepts, created in Macromedia Flash© (www.macromedia.com).

The outcome measures consisted of a nine item multiple choice test over the information studied, and a questionnaire, in which students were asked to rate their agreement-disagreement with eight statements on a nine point scale. These statements were:

1. I learned a great deal of information from the example problems on shear flow.
2. I found that the example problems helped me to better visualize how to apply the shear flow equation.
3. I found the example problems helped me to better understand how to calculate Q.
4. Today's presentation on shear flow helped me to recognize how much I know and don't know about shear flow.
5. I found today's presentation on the shear flow problems to be motivational.
6. Technical problems with my computer hardware or with the software caused me to dislike the computer-based instructional materials that I viewed.
7. I would like to use materials like these again, either in class like today or out of class.
8. Give your overall evaluation of the presentation of the two shear flow example problems, using the 1 ... 9 scale, with 1 = very poor and 9 = outstanding.

### Procedure

Students completed the experiment during their regular class time. This was students first exposure to this material, which is material regularly covered in this class. Four sections, of approximately 25 students each participated. Within each section students were randomly divided into video, text, and multimedia groups. After an initial introduction to the experiment, students watched the initial video lecture for ten minutes, after which they studied the example problems in their assigned conditions for twenty minutes, followed by the test and questionnaire. All study materials were presented on the World Wide Web. The Videos were presented in RealPlayer© (www.real.com). The entire experiment took fifty minutes.

## Results

A series of nine, 2 way, between-subjects analyses of variance (ANOVAs) were computed with experimental condition (video vs. text vs. animation) and GPA (high vs. low, based on a median split) serving as the independent variables. In the first ANOVA test score served as the dependent variable and in the other eight each of the ratings served as a dependent variable.

In the ANOVA in which test was the dependent variable main effect for GPA was found  $F(1,94) = 4.73, p < .05$ , with high GPAs ( $M = 4.18$ ) scoring higher than low GPAs ( $M = 3.24$ ). In the ANOVA in which

students rated their level of motivation, a marginally significant main effect of GPA was also found  $F(1,94) = 3.90, p = .051$  with high GPAs ( $M = 4.46$ ) rating the material as less motivating than low GPAs ( $M = 5.32$ ). No other effects in any of the ANOVAs were significant.

## Discussion

The results indicated that, not surprisingly, higher ability students scored higher on the post test covering the experimental materials, than their peers. In addition, these same high ability students rated their levels of motivation substantially lower than their peers. However, this effect did not interact with experimental condition and, in fact, there was no significant effect for experiment condition across all dependent measures. It did not appear to make an appreciable difference whether a student viewed example problems in the form of a video lecture or static text/graphics or a 3-D animation.

These results are inconsistent with what one might expect since there would appear to be some important advantages to the video lecture and/or the animation. The former was the only method to provide information via two perceptual modalities (which should be advantageous according to the theory of multimedia discussed in the introduction) and the animation would seem to have an advantage in that it was the only method that allowed for the visual representation of 3-D concepts that were an important part of understanding these materials.

There are at least three possible explanations for these somewhat counterintuitive findings. First, the relatively short twenty-minute presentation of the materials may not have been very representative of the way in which these materials would be used in a traditional class. This is the common dilemma researchers face, in that the strength of the study, in terms of internal validity and control, may have negatively impacted the external validity and generalization to applied situations. Second, students motivation level may not have been as high as would normally have been the case if the outcomes test would have counted towards their grade, which was reflected at least in the low motivation levels for those in the high GPA group. Third, the lower-level knowledge assessed via the multiple choice test may not have accurately reflected the additional spatial and applied knowledge that could have been gained by those who were exposed to the 3-D multimedia presentation.

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