Drawing Comparisons:
"What I See, I Remember. What I do I Understand"

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"What I hear, I forget. What I see, I remember. What I do I understand."
Confucius

Abstract

This paper tests "What I see, I remember" against "What I do, I understand" via a study conducted among two sections of freshman Architecture and Construction Engineering Technology students in a course that does not have a laboratory component. The author's preceding investigation had verified previous research demonstrating that the majority of students are visual learners and the addition of visual aids in the classroom realized improved comprehension of course content. A prior study also found that the use of hand-held diagrams resulted in higher learning scores than the use of audiovisuals alone.[1] The goal of this study is to measure the difference in student learning between two groups of freshmen Architecture and Construction Management students that are benchmarked in a prior test. The test group reproduced an energy efficient construction detail, from a handout, as a labeled freehand drawing, and the control group studied the same detail but did not transcribe it. Both groups were given the same time for their task and immediately following both groups were instructed to manually reproduce the detail drawing. Instruction was not a factor in this experiment. The results of this study will provide faculty with an understanding of the relative benefit of having students complete freehand drawings as part of their lecture classes.

Introduction

Since the time of Confucius (born 551 BC) educators have known that while "seeing is remembering, doing is understanding." More recently it has been shown that the majority of students are visual learners[2], yet instructors should present the course content in the mode (visual, auditory or kinesthetic) that best suits the subject matter rather than the students preferred modality.[3] Teaching a lecture course that is not supplemented by a laboratory component may offer a few challenges to 'doing is understanding' and hands-on kinesthetic learning if the subject matter is a topic such as the construction of a foundation, or an energy efficient wall to roof detail. Other than incorporating field trips to construction sites and model building – which time may not permit – the use of videos, slides and construction details prevail.

Over the course of their college education, engineering students in lecture style classrooms are shown visual aids to enhance spatial thinking in a variety of forms and from many sources. Spatial thinking is "the mental manipulation of objects and their parts in 2D and 3D space."[4] One type of spatial material is symbolic representation,[5] which includes graphs, drawings and diagrams from a variety of sources such as classroom presentations, textbooks and online research. According to Newcombe, "spatial training has been found to improve educational outcomes, such as helping college students complete engineering degrees."[6]

Today, students are less likely to reproduce graphs, details and diagrams that were once drawn by their instructor on the blackboard. Diagrams and drawings are now often referred to out of textbooks, placed on handouts, PowerPoint slides and audiovisuals, uploaded to the Internet as sets of lecture notes for students to refer to after their lecture, or the course is offered completely online. (As an aside, a 1981 study showed that students who used their own notes scored nearly twice as high as students who used notes either given to them by the teacher or from another student.[7]) The active process of copying drawings and diagrams by hand as part of note-taking is turning into passive observance and a procrastinated review of supplied information immediately prior to an examination.

The goal of this paper is to further the author's study of the use of visual aids in classrooms that are not supplemented with a laboratory component for hands-on learning. The visual aid being tested is one type of symbolic representation – a construction detail. In this study, student retention after examining a labeled hand-held detail drawing without reproducing it is compared to student retention after manually reproducing the same labeled detail. The experiment's outcome provides faculty with an understanding of the relative benefit of encouraging students to complete freehand drawings as part of their lecture classes.

Methodology

A total of 32 freshmen Architecture and Construction Management students, separated into two groups of 16 (n=16) were benchmarked in a prior test that showed that the two groups were of equal aptitude. All students tested were enrolled in a separate graphics course in manual drafting. Both groups were then separately given the same energy efficient construction detail that had 12 labeled parts, on a paper hand-out, for 15 minutes. The detail drawing represented a new topic that had not been previously discussed in class. Faculty instruction is therefore not a factor in this experiment.

The control group was instructed to study the handout without holding a writing implement or using any digital device. Therefore, note taking and/or the replication of the information in any manner was not permitted. The test group was instructed to make one freehand sketch of the detail with labels on a separate blank sheet of paper. At the end of the fifteen minutes the freehand reproduction sketch of the construction detail was collected from the test group, and the handout of the construction detail was collected from both groups. Each group was then given a 15 minute test that required each student to draw a labeled freehand sketch from memory of the detail that they had reviewed or drawn. Drawings were sketched on blank paper supplied by the instructor.

The students' tests were evaluated by comparing the students' labeled freehand drawing with the original labeled energy efficient construction detail handout. The maximum score possible score was 12 points.

Results

Drawing Comparisons Test Results			
	Control Group Scores (Review only, out of 12)		Test Group Scores (Redraw, out of 12)
	4		3
	5		4
	5		7
	5		7
	5		7
	6		9
	7		9
	7		11
	7		11
	8		11
	8		12
	8		12
	8		12
	9		12
	10		12
	10		12
Average	7		9.4375
%	58.33%		78.65%

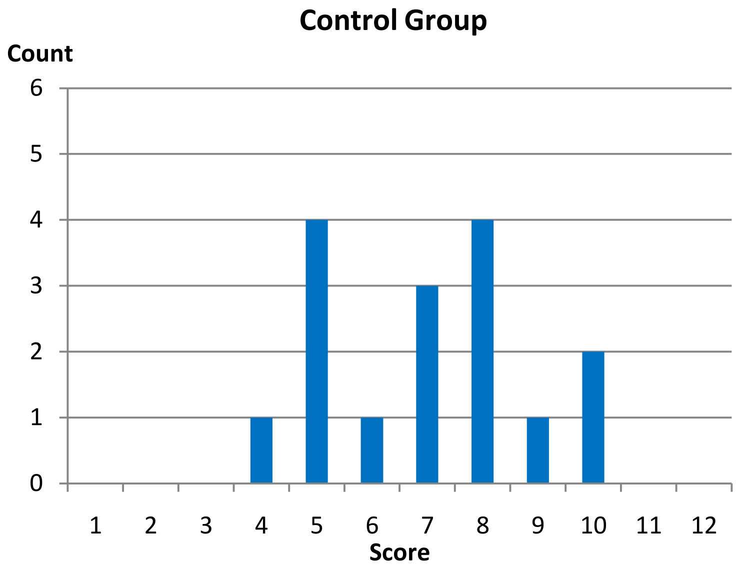
Control Group		Test Group	
Score	*Frequency*	*Score*	*Frequency*
1	0	1	0
2	0	2	0
3	0	3	1
4	1	4	1
5	4	5	0
6	1	6	0
7	3	7	3
8	4	8	0
9	1	9	2
10	2	10	0
11	0	11	3
12	0	12	6

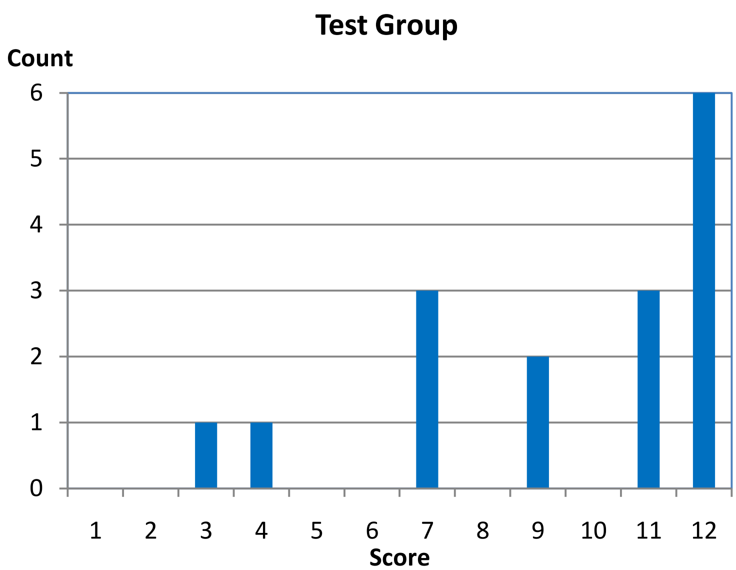
One-Tailed Two-Sample t-Test for Unequal Variances (Welch's t-Test)

α = 0.05

	Control Group	*Test Group*
n	16	16
Median score (out of 12)	3	4.5
Mode	5, 8*	12
Mean score	7	9.438
Variance	3.467	9.063
t Statistic	-2.75	
t Critical	1.71	

* Control group results are bi-modal, but sufficiently normal.





The results above indicate that ‘seeing is remembering,’ at an average 58.33 % compared to ‘doing is understanding’ with 78.65%. The test group yielded on average a 2 letter grade improvement in learning performance. Therefore, there is a relative benefit of having students make their own freehand sketches of details, diagrams, drawings shown in class rather than supplying the information on a handout.

In a previous study by the author it was found that studying a construction detail provided a more effective means of introducing a new topic than viewing a video of the same topic. With the results of the present paper showing that there is higher student retention associated with actively drawing a detail than studying the same detail, it can be extrapolated that students who make freehand sketches of spatial material during a lecture will outperform students who only watch a video of the same topic.

Discussion

The results of this study show that students who actively draw a freehand reproduction of a labeled drawing attain a higher level of understanding than those who study the same material without reproducing it by hand when tested immediately after their review.

Contero et al found that there are three important instructional elements for the future engineer: "spatial visualization, freehand sketching and normalized view generation."[8] Engineers and architects use freehand sketches during the exploratory phase of design to capture and assemble ideas.[9] Alias et al reported that the spatial visualization ability of civil engineering students can be improved though spatial activities consisting primarily of object manipulations and free hand sketching.[10]

Students who sketch subject matter as part of a lecture have been shown to have improved comprehension and retention when compared to those who do not sketch.[11] Freehand sketching in otherwise non-graphic courses aids with design visualization skills,[12] is one of the most frequently used activities for improving spatial abilities,[13] and is basic to effectively capturing thoughts and cognitive processes.[14]

A 1993 ASEE study rates "writing, speaking and freehand drawing/graphic communication requirements across the curriculum 2nd in importance to "problem recognition and solution skills." [15] A subsequent study by McArthur and Wellner found that where there was a decreased focus on spatial ability training, students' spatial thinking and ability suffered.[16] According to Mohler and Miller, digital tools are also responsible for decreasing "the perceived need to engage in practical activities such as drawing and sketching in the classroom."[17]

The need for freehand sketching was once again illuminated in a 2004 Engineering Design Graphics Division survey of the ASEE. This survey found that "the ability to sketch engineering objects in the freehand mode" and the "ability to create 3-D solid computer models" were the "two most important graphical communication outcomes for engineering students."[18] Therefore design engineers still need the ability to create freehand drawn sketches.[19]

Mohler and Miller's study on mentored sketching in a graphics course states the following benefits of sketch-based notes. This list is included as it has potential benefit to all courses with details, drawings, graphs and diagrams:

"The observed advantages of sketch-based notes are that they:

- Encourage students to attend the lectures.
- Allow for an interactive lecture where students cannot lose interest.
- Allow students more experience constructing engineering sketches.
- Help to advance the spatial abilities of the students.
- Allow the instructor to do mass mentoring of proper sketching techniques.
- Provide an opportunity for greater interactivity between the instructor and the students."[20]

Conclusion

The results of this paper indicate that students who reproduce course material such as labeled freehand sketches, achieve a higher rate of learning than students who do not recreate freehand drawings of the same material. Therefore faculty are encouraged to require students to reproduce visual lecture material into their notes as freehand sketches rather than providing the students with the same material via passive media such as handouts, slideshows and online presentations. Further research on this topic with larger sample sizes and more course topics is suggested.

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