The Digital Whiteboard As a Notes-Taking Aid

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Summer 2000

Abstract
Students must decide how to use class time – taking a complete set of lecture notes, often without thinking about the material, or processing the material covered in the lecture, forming associations and elaborating on the meaning. Because of limited time, often both tasks cannot be concurrently performed. Digital whiteboards offer the ability to record what is written on them, and this information can then be placed on the World Wide Web. This might free some of the students' time from taking notes and might allow the students to process the information more deeply, which might lead to better retention and comprehension of the material. Conversely, the students could stop taking notes and stop thinking, which might lead to worse retention and comprehension of the material. A study was conducted across two sections of an elementary statistics for the social sciences class. One section had web-based access to copies of information written on a digital whiteboard for the first and fourth quarters of the semester and no access for the second and third quarters. The other section did not have access during the first and fourth quarters, but did have access during the second and third quarters. The results failed to reveal the predicted interaction between section of the class and exam such that those with web-based access to the whiteboard information should perform better than those without access. Several possible explanations for this result are ruled out including a lack of use of the web-based information, and having web-based notes leads to less attention in class.

The Digital Whiteboard As a Notes-Taking Aid

Students often are faced with a dilemma: should they spend most of their time in class attempting to copy down everything that is said in a class so that they will have a complete set of lecture notes or should they spend most of their time in class trying to comprehend what is said and trying to associate it with pre-existing knowledge. Ideally, the student should do both, but realistically, there often is not time to accomplish both goals in a class.

Craik and Tulving (1975) suggest that the student's impressions are correct – if the student spends most of the class taking complete notes then they may not understand the material. But if the student spends most of the class thinking about the material, then they may not have a very complete set of notes. Craik and Tulving hypothesized that the retention of a list of words is not determined solely by the amount of time spent studying the words, but also by the way the words are studied. They suggest that there are at least three qualitatively different ways (or levels) of processing information that can lead to different degrees of retention.

In the structural level of processing, one looks only at the features of the to-be-remembered words. For example, one might attend primarily to whether the word is written in upper versus lower case or whether the third letter in the word is an "e." Craik and Tulving suggest that the surface level of processing should lead to the poorest level of retention because the meaning of the word is not activated and therefore the word cannot be easily associated with pre-existing knowledge. The surface level of processing may be the way that most students take notes in a lecture – the students copy down whatever is said or written without having time to think about the meaning of the material.

In the second of Craik and Tulving's levels of processing, phonemic, one attends primarily to the sound of the word. For example, one might see a word and then decide if the word rhymes with another word. Craik and Tulving predict that the phonemic level of processing will lead to better retention that the structural level.

Craik and Tulving's final level of processing, semantic, is predicted to have the greatest retention. In the semantic level of processing, the meaning of the word is accessed and this allows the words to become associated with whatever pre-existing knowledge may exist. The semantic level would correspond to a student who primarily thinks about the meaning of the material being presented.

In a series of 10 experiments, Craik and Tulving (1975) presented a word followed by a question. Sometimes the question oriented the students to the structural aspects of the word ("Was the word in upper case?"). Sometimes the question oriented the students to the phonemic aspects of the word ("Does the word rhyme with CAT?"), and sometimes the question oriented the students to the semantic aspects of the word ("Was the word a type of animal?"). After many such word-question pairs were presented, the students were given a memory test for the words. Consistently, the students remembered more words that had the semantic orienting question than words that had the phonemic orienting questions, which had more words remembered than the structural orienting question. Thus, one can reasonably conclude that the type of processing that one performs on to-be-remembered material can influence the extent to which the material is retained.

If an instructor could free a student from copying down word-for-word notes, then perhaps the student could spend less time on the structural level components of the material and more time thinking about the meaning of the material. Craik and Tulving's (1975) results suggest that that could lead to greater retention of the material. By using a digital whiteboard that records everything that is written and then posting that material on the World Wide Web for the student to access, one may be able to achieve this goal.

A potential downside to this is that some students may rely entirely on the posted material for their notes and stop thinking while they are in class. If the student is neither thinking about the meaning of the material, nor taking notes, then they will not even benefit from Craik and Tulving's (1975) lowest level of processing and therefore should have particularly bad retention of the material.

It is predicted that students who have web-based access to the information written on the whiteboard will not have to take as extensive notes and therefore have time to process the material to a deeper level and thus retain the information better than those who do not have access. This will especially be true if the students do not pay less attention in class because they do not have to take notes. This hypothesis will be tested by allowing students in one section of a class web-based access to the information written on the whiteboard when material for the first and fourth exams is presented and not for the second and third exams. A second section of the class will have access when material for the second and third exams is presented, but not for the first and fourth exams. Thus, there should be an interaction of exam number and section of the class.

Method – Participants

The participants were 23 female and 7 male undergraduate students enrolled in an elementary statistics for the social sciences class. These students had a mean age of 19.8 years at the start of the experiment. An additional five female and five male students failed to finish the class. The students self-selected their enrollment into either the 11 AM (N = 16) or noon (N = 14) section of the class. The students were treated ethically (American Psychological Association, 1992.)

Method – Design

Students were either allowed web-based access to the information written on the whiteboard or not. Students who self-selected to be in the 11 AM section of the class had web-based access to the information written on the whiteboard during the first and fourth quarters of the semester. They did not have access to that information during the second and third quarters of the semester. Students who self-selected to be in the noon section of the class had web-based

access to the information written on the whiteboard during the second and third quarters of the semester and did not have access during the first and fourth quarters.

Performance on each of four exams was recorded. A questionnaire measured self-reported attitudes toward and usage of the whiteboard writings.

Method – Materials

A SMART Board model 560 digital whiteboard was used in the class. The SMART Notebook 2.11 software captured the contents of the digital whiteboard and formatted it for web presentation (see the White Board Writings at **http://elvers.stjoe.udayton.edu/psy216/216.htm**). The web site was hosted on an IBM compatible computer using Microsoft's Internet Information Server (version 4) web server software under Windows NT Server (version 4). A user name and password was created for each student so the web server could allow only students in the appropriate section of the class access to the copies of the information written on the whiteboard.

Each exam consisted of 25 multiple choice questions (each worth 2 points) and 5 essay / problem questions (each worth 10 points). Exams similar in style and content to the ones used in the experiment can be found on the class web site at the previously mentioned URL.

A two-page questionnaire (see the Appendix) was created to determine the student's self-reported usage of the web-based copies of information written on the whiteboard and their attitudes toward having the information available.

Method – Procedure

The digital whiteboard was demonstrated on the first day of class. At the start of the second day of class, the students in the 11 AM class were shown how to access the web-based copies of the information written on the whiteboard and were encouraged to used that information. These students could access the copies of the information written on the whiteboard by accessing the class web-site. The material was posted on the web-site no later than 2 PM on each class day.

Students in the noon class were not shown how to access the web-based copies of the information written on the whiteboard until just after the first exam. At that point the students in the 11 AM class were informed that they would not have access to the web-based copies of the information written on the whiteboard until just after the third exam. Just after the third exam, the students in the noon section were told that they would not have access to the web-based copies of the information written on the whiteboard any more. The four exams were given at approximately equally spaced times throughout the semester. After taking the final exam, the students filled out a two-page questionnaire that addressed their usage of and attitudes toward the web-based copies of the information written on the whiteboard.

Results

The prediction stated that students who had access to copies of the information written on the digital whiteboard should perform better on each exam than those who did not have access to copies of the information written on the digital whiteboard. Thus, there should be an interaction of exam number (1 through 4) and section (11 AM vs. noon) such that for exams one and four, the 11 AM section, which had web-based access to the information written on the whiteboard, should out perform the noon section, which did not have web-based access to copies of the information written on the whiteboard. For exams two and three, the noon section, which had access to the information written on the whiteboard, should outperform the 11 am section, which did not have access.

Figure 1 shows the mean performance for each section for each exam. A two-way, mixed design, analysis of covariance (ANCOVA) was performed with section (between-subjects) and exam number (within-subjects) as the factors, exam performance as the dependent variable and grade point average (GPA) upon entering the class as the covariate. GPA was used as a covariate in an

attempt to statistically equate the initial abilities of the two sections of the class. The ANCOVA failed to reveal the predicted interaction $F(3, 81) = 0.91$, $p = .44$, a = .05, $MSE = 51.39$. The ANCOVA revealed a significant main effect of section, with the 11 AM section (marginal M = 82.21, estimated at GPA = 3.13) outperforming, on average, the noon section (marginal M = 76.03, estimated at GPA = 3.13), $F(1, 27) = 7.38$, $p = .01$, MSE = 149.78. The ANCOVA also revealed a significant main effect of exam number with performance tending to decrease with each successive exam, $F(3, 81) = 9.24$, $p < .0005$.

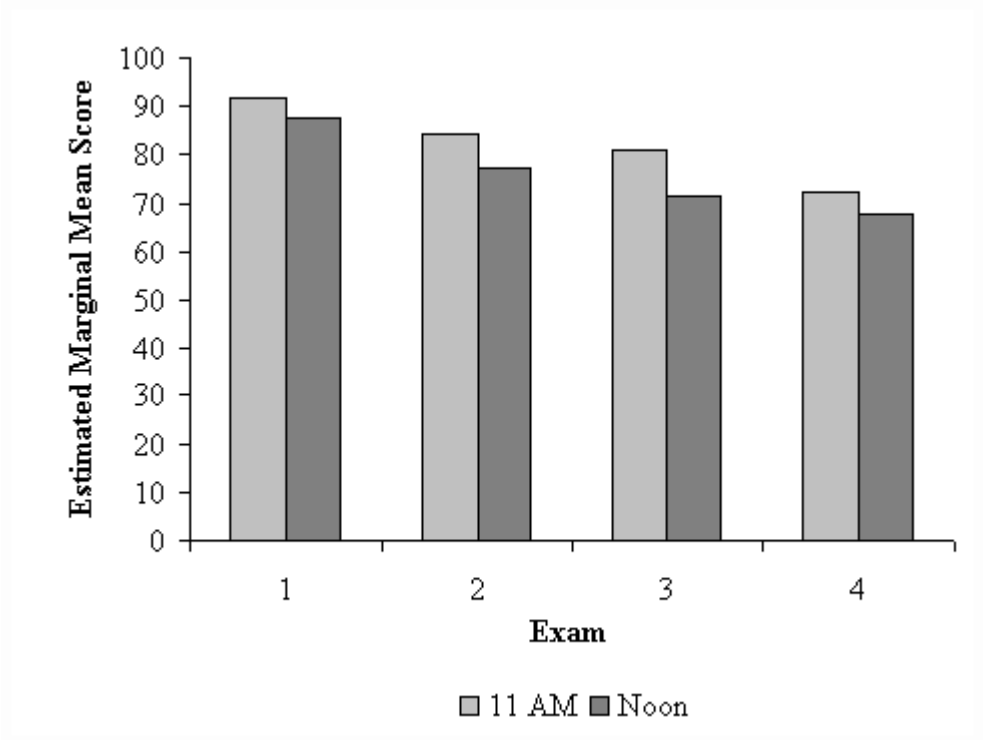

Figure 1. Marginal mean scores for each exam estimated at a GPA value of 3.13. For the material covered on the first and fourth exams, the 11 AM section of the class had access to the digital whiteboard writings posted on the World Wide Web while the noon section did not. For the material covered on the second and third exams, the 11 AM section of the class did not have access to the digital whiteboard writings while the noon section had access. The interaction of exam number and section is not statistically reliable. The figure shows that the 11 AM section outperformed the noon section regardless of whether they had access to the whiteboard writings or not. This is true even after adjusting for possibly different GPAs between the classes.

Table 1 shows the results of the eight questions on the post-study questionnaire. One-sample *t* tests compared the mean response of each question to 3 (the neutral response point). As shown in Table 1, the mean response to the "When the digital copies of the contents of the whiteboard were available to me, I found them useful," and to the "When the digital copies of the contents of the whiteboard were available to me, I could think more about what was being said in class" questions were both reliably above 3. This implies that the students tended to agree with these statements. The mean response to the "When the digital copies of the contents of the whiteboard were available to me, I paid less attention in class" question was reliably below 3. This implies that the students tended to disagree with this statement.

Table 1
Frequency of Responses to the Eight Questions on the Post-Experiment Questionnaire

	Strongly Disagree	Dis-agree	Neutral	Agree	Strongly Agree	Mean	df	*t*	*p*

When the digital copies of the contents of the whiteboard were available to me, I used them regularly.	7	5	3	10	5	3.03	29	0.12	.902
When the digital copies of the contents of the whiteboard were available to me, I found them useful.	2	4	7	11	5	3.45	28	2.10	.045
When the digital copies of the contents of the whiteboard were available to me, I could think more about what was being said in class.	3	3	2	18	3	3.52	28	2.42	.023
When the digital copies of the contents of the whiteboard were available to me, I paid less attention in class.	8	18	1	2	0	1.90	28	7.70	.000
I learned more when the digital copies of the contents of the whiteboard were available to me than when they were not available to me.	6	4	4	10	5	3.14	28	0.52	.608
I think that my grade in the class would have been higher if the digital copies of the contents of the whiteboard were always available to me.	6	6	7	8	2	2.79	28	0.88	.386
When the digital copies of the contents of the whiteboard were available to me, my notes were more accurate.	4	6	6	11	2	3.03	28	0.15	.879
When the digital copies of the contents of the whiteboard were available to me, my notes were more complete.	3	4	7	12	3	3.17	29	0.71	.484

Discussion

The predicted interaction of exam number and section was not supported by the data. There are several possible explanations for this. First, it is possible that the students did not regularly use the web-based copies of the information written on the whiteboard and therefore could not benefit from them. This explanation is partially supported by the fact that the mean response to the question about the regular usage of the web-based copies of the information written on the whiteboard (question 1 on the post-study questionnaire) was not reliably different from the neutral response (see Table 1.) As a test of this hypothesis, the ANCOVA discussed in the results sections was repeated on just the data from students who either agreed or strongly agreed with the regular usage question (question 1) (N = 15). However, the predicted interaction of section and exam number still was not statistically reliable, $F(3, 36) = 0.24$, $p = .87$, $MSE = 61.63$.

A second possible explanation for lack of an exam number by section interaction is that students who more frequently used the web-based copies of the information written on the whiteboard might have paid less attention in class. The benefits of having accurate notes may have been cancelled by the costs of being more passive in class. If this was a reasonable explanation, there should be a positive correlation between questions 1 (used the information written on the whiteboard regularly) and 4 (paid less attention when the copies of the information written on the whiteboard were available.) Pearson's r for these two questions was not statistically reliable, $r = .30$, $p = .12$.

A third possible explanation is that the web-based copies of the information written on the whiteboard were not beneficial for this particular course. The course has an extensive web site with lecture notes corresponding to the PowerPoint presentations already available to the students. The whiteboard was used when working out problems, answering questions, or clarifying points made in the lecture. Perhaps the students simply found it easier to copy this information down than to go to the web site and access it. For example, one student in the open-

ended question on the post-experiment questionnaire stated "I didn't find that they [the whiteboard information on the web-site] were helpful. It was just easier to copy what he wrote on the slide [pre-existing lecture notes available to the students] it pertained to." Perhaps the copies of the information written on the whiteboard would be more useful in a class in which the whiteboard was used as the primary means of delivering content to the students.

Even if the web-based copies of the information written on the whiteboard did not influence the student's performance on the exams, they did influence the student's attitudes toward the class. From the post-experiment questionnaire, the student found the web-based copies of the information written on the whiteboard useful and reported that they could think more about what was being said in class. Anything that can improve student's attitudes about a required course that many students find difficult and challenging is positive.

In addition to the student's perspective, the pedagogical impact of the whiteboard is also important. In this particular class, statistical software is demonstrated at several times during the semester. The digital whiteboard is an excellent tool for teaching software usage. In the past, I was often going to the computer to show a command and then back to the screen to show the results of the data analysis. Then I would have to use the (non-digital) whiteboard to show the students how to interpret the output of the software. This process was awkward and time consuming. With the digital whiteboard, all of these functions can be performed at one place with great ease.

Future research could address whether the copies of the information written on the digital whiteboard would be useful in a class that did not have extensive, pre-existing web-based notes. It would also be interesting to see if the information written on a whiteboard during a lecture-based class could be useful for a distance-learning section of the same class. Other research possibilities that might have an influence on the results are personality factors, such as openness to new experiences (McCrae & Costa, 1987) – students who are not open to new experiences may be less willing to use the web-based copies of the information written on the whiteboard while students who are more open to new experiences may be more willing to using the information.

While the web-based copies of the information written on the whiteboard did not reliably influence the performance of the students on the exams, the students reported finding them useful and believed that they could think more about what was said in class because the whiteboard information was available. The digital whiteboard is also an excellent tool for the instruction on the usage of software.

References

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Appendix

The following questionnaire was distributed after the students took their final exam. The responses to the first eight questions were on a five point Likert scale with 1 indicating strong disagreement with the statement and 5 indicating strong agreement with the statement.

Please circle the response that most closely matches your behavior or attitudes. You may leave any or all of the questions blank. The instructor will not look at your responses before the final class grades have been submitted.

1. When the digital copies of the contents of the whiteboard were available to me, I used them regularly.

2. When the digital copies of the contents of the whiteboard were available to me, I found them useful.

3. When the digital copies of the contents of the whiteboard were available to me, I could think more about what was being said in class.

4. When the digital copies of the contents of the whiteboard were available to me, I paid less attention in class.

5. I learned more when the digital copies of the contents of the whiteboard were available to me than when they were not available to me.

6. I think that my grade in the class would have been higher if the digital copies of the contents of the whiteboard were always available to me.

7. When the digital copies of the contents of the whiteboard were available to me, my notes were more accurate.

8. When the digital copies of the contents of the whiteboard were available to me, my notes were more complete.

Please write any additional comments that you have about the use of the digital whiteboard in class.

Author Notes

This research was supported by a grant from the SMARTer Kids Foundation.

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Author Biography

Greg Elvers teaches undergraduate statistics, research methods, and perception in the Department of Psychology at the University of Dayton. He received his PhD in cognitive psychology from Purdue University in 1989. His current research interests include the impact of the use of technology in the classroom, ways of improving the amount learned and the subjective impressions of being part of a learning community in distance-learning settings, and visual and alarm displays.

Project Background

The University of Dayton is a medium-sized, Catholic university located in Dayton, Ohio. The university is actively creating a learning village by networking the student neighborhood around the campus. The learning village will promote a connected campus community where students and faculty collaborate in learning and research and service projects.