Note-taking, cognitive load and word recall in different media environments

Lin Lin and Chris Bigenho

Department of Learning Technologies
University of North Texas, Denton
(Submitted to AERA July 2009, under review)

Abstract:

The study investigates students' abilities to recall words in three media environments: no-distraction, auditory-distraction, and auditory-visual-distraction settings. The study further examines the roles that note-taking tools – no note-taking, note-taking-on-paper, and note-taking on-a-computer – play in these settings. Nine experiments, each with a total of 21-47 undergraduate student participants were conducted. Results indicated that there were significant interactions between environments and note-taking tools. In the no-distraction environment, the participants performed best while taking notes on paper, second best while taking notes on computer, and third while not taking notes. However, in the auditory-visual distraction environment, the participants performed word recall best while not taking notes, second while taking notes on the computer, and third while taking notes on paper. Implications are discussed.

1. Objectives or purposes

Learning environments have become increasingly complex with new media and technologies. Whether learning online or offline, we experience an increasing amount of auditory and visual information from computers and mobile technologies which occupies and competes for our attention and senses. Similarly, the tools that we have available to assist learning are evolving, for instance, more students are typing notes into their laptops instead of handwriting them in their notebooks. However, we do not know all the impacts of the increasing technology equipment in classrooms or of the increasing technology-assisted tools for learning. It doesn't always happen that the more technologies the better.

The purpose of this study, therefore, is to understand how these evolving environments are interacting with the cognitive use of note-taking tools for learning. Such an understanding is important for understanding how learning environments and tasks should be constructed for maximized learning. While long-term memory is usually the target for studies in learning, this study is looking at the impact on cognition caused by the interactions of environments and note-taking tools. We investigated students' abilities to recall words in three different media environments: one with no-distraction, one with audio distraction, and one with audio-visual distraction. Additionally, we examined the roles that note-taking tools, including note-taking on paper, note-taking on computer, and no note-taking, played in students' abilities to recall the words. The three media environments combined with three note-taking tools formed nine experiments. We intentionally built "distraction," i.e., the additional information unrelated to the information to be recalled, into the design of the experiment, for the purpose of focusing on the interactions between note-taking tools and environments.

2. Perspective(s) or theoretical framework

Research on note-taking has produced mixed results: some show that students improve their recollection of information when taking notes (Bligh, 2000; Howe, 1970; Johnston & Su, 1994; Kiewra, et. al, 1991), some indicates that there is no difference between taking notes and not

taking notes (Kiewra, 1985), and some demonstrate that students fail to record the most important points when they take notes (Hartley & Cameron, 1967; Howe, 1970; Kiewra, 1985). Whether taking notes helps or not probably depends on the cognitive load that the students can handle in the note-taking process (Baddeley, Chincotta, & Adlam, 2001).

Cognitive load theory (Sweller, 1988) suggests that a learner carries three forms of cognitive processing load: intrinsic load, extraneous load, and germane load. Intrinsic load is imposed by the nature and difficulty level of the new information; extraneous load is imposed by the instructional methods and materials; and germane load is the mental process of taking new information and integrating it with old information in order for the learning to occur. The total cognitive load of the three added together should not exceed the cognitive processing resources of the learner, or learning shuts down under excessive or over load. Therefore, the extraneous load, the most easily manipulated load of the three by instructional design, must be minimized so as to maximize the cognitive resources available for the learner to process the intrinsic and germane loads, leading to improved learning outcomes (Kirschner, 2002). Paivio presents a Two-Channel Theory (1986), which models information input to a learner as entering only through two channels: a vocal channel (the processing of words) and a visual channel (the processing of images). This theory argues that it is easier for a learner to utilize attentive resources on two tasks differing in nature (one a word-task, the other an image-task) than on two similar tasks (two word-tasks or two image-tasks).

A good multimedia design minimizes the extraneous cognitive load by filling multiple senses and channels of the learner with complementary information without redundancy, confusion, or an over-reliance on working memory (Miller, 1956; Sweller, 1988). One of the benefits of Multimedia User Virtual Environments (MUVEs) is the richness and complexity of the information they can display, creating something closer to a real-world environment (Dede, 2003; Dede, Ketelhut, & Reuss, 2003; Nelson, Ketlhut, Clark, Browman, & Dede, 2005), utilizing ill-defined learning outcomes and processes (Barab, Thomas, Dodge, Carteaux, & Tuzan, 2005; Jonassen, 1999), and requiring a complex set of interactions (Bruckman, 2000) to increase participant engagement and cognitive processing. Similarly, computer-based learning environments incorporate text, video, and pictures to load the learner's input channels in a complementary manner and enrich the learner's experiences (Clark & Mayer, 2003). One of the concerns educators have had about these systems is the possibility that multimedia streams not directly supporting the material could have a distracting effect on the learner and could actually impede the intended learning (Nelson & Erlandson, 2008).

3. Methods, techniques, or modes of inquiry

This study follows an A x B design with three levels for each factor creating nine experimental conditions (Table 1). All participants were to participate in all nine conditions. The two experimental factors for this study were Environment and Note-taking Tool.

Participants watched a total of nine videos of 20 words each. Each video was two minutes in length and displayed a single target word in the center of the screen. Each target word was presented for five seconds. We instructed participants to memorize as many words as they could. Immediately following completion of each video, participants were given a simple recall task followed by a second recall task one hour later.

We assigned one of three environmental conditions to each video: no distraction, auditory distraction, and auditory-visual distraction. The three clips assigned to the condition of no distraction were silent and simply displayed the target word. The three clips assigned auditory distraction included a conflicting spoken word at the presentation of each target word. There were no further distractions visually. The three clips assigned the auditory-visual distraction condition layered two conflicting videos and their existing audio as flankers. These clips also included auditory conflict of the spoken word. The videos were presented in the upper left and lower right corners of the screen. While watching the video, the participants were also assigned a second task, i.e., a possible note-taking task: no note-taking, note-taking on paper, or note-taking on the computer. In all cases, the target words were presented in the center of the screen and all were of the same font and size. There were a total of nine lists of words consisting of 20 words each.

Table 1: Mean scores and standard deviations (number of correct answers) for 21 participants under three media environments and three note-taking tools (a total of nine experiments)

Environmental Conditions	***Note-taking Tools***	***Mean***	***S.D.***
No Distractions	No-note-taking	9.33	3.17
	Taking-notes-on-paper	13.00	3.63
	Taking-notes-on-computer	9.81	2.89
Auditory Distraction	No-note-taking	9.00	2.97
	Taking-notes-on-paper	10.81	3.27
	Taking-notes-on-computer	11.14	4.43
Auditory and Visual Distraction	No-note-taking	9.57	4.30
	Taking-notes-on-paper	8.24	3.39
	Taking-notes-on-computer	8.95	4.01

4. Data sources, evidence, objects or materials

The experiments lasted nine weeks, with one experiment per one week. The initial participant pool consisted of 47 undergraduate pre-service teachers in a computer education course. There were 43 female and 4 male participants in our study. However, not all students attended classes every week. Consequently, only 21 students completed all the nine experiments. With this paper, we only included results from these 21 participants in the analysis (n = 21). The average participant age was 22 years with a range of 19 to 25 years.

The participants were given a simple memory recall task after watching a short video that presented target information in one of the nine experiments. After viewing the video, they logged their answers using an online survey tool. The results were then tallied creating values for the number of correct responses for each task. Participants were also encouraged to respond to several open-ended questions that would help inform us of strategies and participant experiences. However, this qualitative data has not been coded or analyzed at the time of this proposal but will be included in the final paper.

5. Results and/or substantiated conclusions or warrants for arguments/point of view

The collected data was coded and entered into a relational database allowing for each participant's results to be tracked and sorted according to the analysis being run. The mean number of correct responses for each experiment can be found in the Table of Means (Table 1).

Next, we ran a 2-way ANOVA in SPSS on the experimental variables: Environment and Note-taking. This analysis focused on the number of correct responses recorded by each participant under each of the nine conditions. We can report that there was a significant main effect of Environment, $F(2,40) = 6.71$, $p = .003$. It did not come as a surprise that the more complex the environment became where the target was being presented, the greater the impact on the number of words recalled correctly during the recall task. The effect here was that the recall accuracy decreased as the complexity of the environment increased. However, the main effect of Note-taking was not significant to marginally significant, $F(2,40) = 2.71$, $p = .079$. This did not match our expected outcome. We are looking at additional analysis here to see if more can be understood about this effect. The reduction in the number of participants (n=21) compared to the subject pool (N= 47) is something that we are exploring through z-score transformations followed by additional statistical testing. We are attempting to capture some of the data that was lost when we excluded participants who did not complete all nine conditions. The interaction of Environment and Note-taking was highly significant, $F(4,80) = 9.78$, $p < .01$. The level of significance in this interaction leads us to believe we need to look closer at Note-taking tools in future studies.

Looking closer at the interaction of Environment and Note-taking Tool, we find that note-taking-on-paper and note-taking-on computer interacted with the environment while the act of not taking notes provided little interaction (figure 1). In addition, it appeared that: 1) when there was no distraction, the participants performed best while taking notes on paper, second while taking notes on the computer, and third while not taking notes; 2) when in auditory distraction environment, the participants performed best while taking notes on the computer, second while taking notes on paper, and third while not taking notes; 3) when in auditory and visual distraction conditions, participants performed best while not taking notes, second while taking notes on the computer, and third while taking notes on paper.

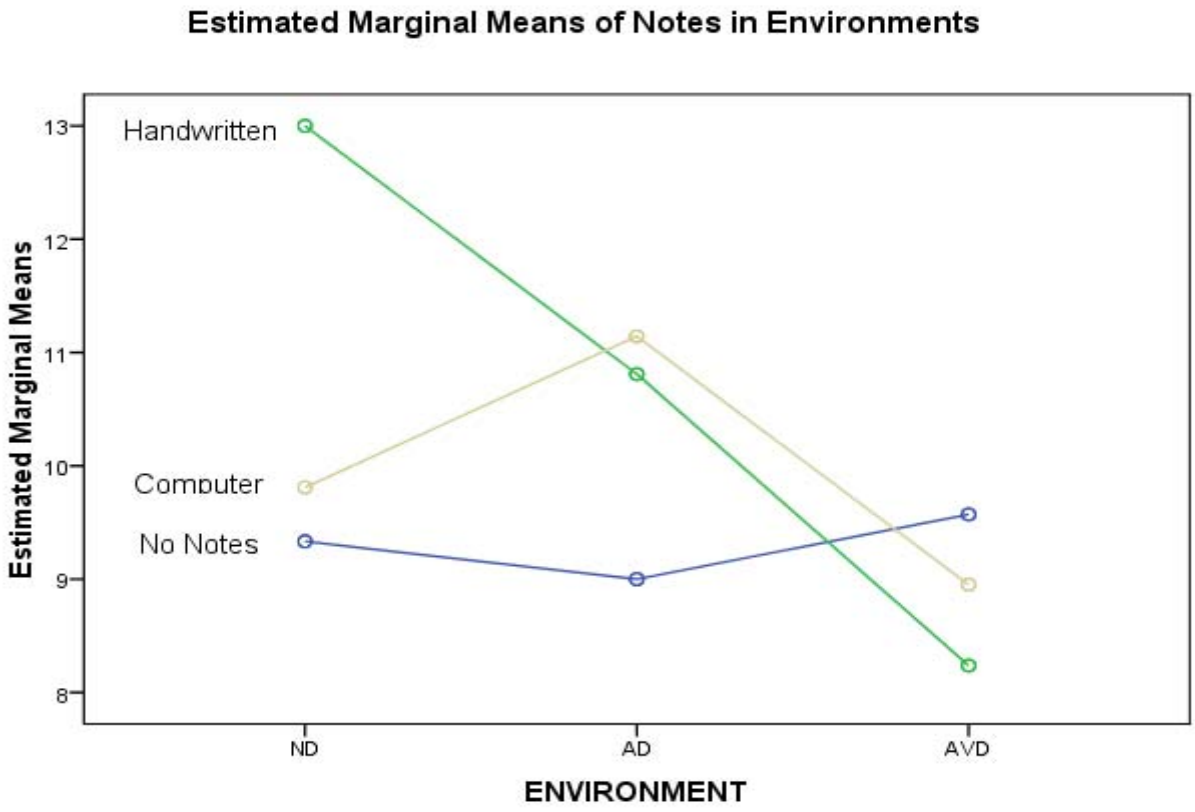

Figure 1. The marginal mean scores of the participants' word recall (discrete points) in three environments (ND: No Distraction; AD: Auditory-Distraction; AVD: Auditory-Visual-Distraction) and with three different note-taking tools (no-note-taking, -note-taking-on-computer, and paper-note-taking-on-paper)

6. Scientific or scholarly significance of the study or work

Our largest limitation was the number of participants who completed all levels of the study. While we are working through statistical techniques to capture more information, this is something we will have to consider in future iterations of this study. The words used as target words may also need further review. Paivio (1969) found that concrete and high-imagery words resulted in stronger memory than more abstract words and low-imagery words. While we attempted to equalize the lists for number of syllables and familiarity of the words, participants noted in their comments that some of the lists seemed easier to remember.

The initial findings indicate that in non-distractive environment, one should take notes by hand on paper. When the environment is expected to be highly distracting with both auditory and visual inputs, the best option is not to take notes but focus on the task. Even so, one still only picks up less than 50% of the total information being presented. When there is only auditory distractions, taking notes on the computer can be a preferred option. We believe these findings are sufficient to warrant further studies in this area to validate these results, and to further examine what different note-taking tools mean for learning in multimedia environments.

7. Reference

Baddeley, A., Chincotta, D., & Adlam, A. (2001). Working memory and the control of action: evidence from task switching. *Journal of Experimental Psychology: General*, 130(4): pp. 641-657.

Barab, S. A., Thomas, M., Dodge, T., Carteaux, R., & Tuzan, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology, Research, and Development*, 53(1): pp. 86-108.

Bligh, D. (2000). What's the use of lectures? San Francisco: Jossey-Bass.

Clark, R. C.; Mayer, R. E. (2003). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*. San Francisco: Pfeiffer.

Dede, C. (2003). Multi-user virtual environments. *Educause Review*, 38(3): pp. 60-61.

Dede, C., Ketelhut, D. J., & Reuss, K. (2003). *Motivation, usability, and learning outcomes in a prototype museum-based multi-user virtual environment*. Paper presented at the Fifth International Conference of the Learning Sciences.

Jonassen, D. H. (1999). Designing constructivist learning environments. In Reigelugh (Ed.), *Instructional design theories and models: A new paradigm of instructional theory (Vol. 2)*: pp. 217-239. Mahwah: Lawrence Erlbaum Associates, Inc.

Johnstone, A.H., & Su, W.Y. (1994). Lectures – a learning experience? *Education in Chemistry, 31*, 75-76, 79.

Hartley, J., & Cameron, A. (1967). Some observations on the efficiency of lecturing. *Educational Review, 20,* 30-37.

Howe, M.J. (1970). Notetaking strategy, review and long-term retention of verbal information. *Journal of Educational Research, 63*, 285.

Kiewra, K.A. (1985). Providing the instructor's notes: An effective addition to student notetaking. *Educational Psychologist, 20,* 33-39.

Kiewra, K.A., DuBois, N.F., Christian, D., McShane, A. (1988). Providing study notes: Comparison of three types of notes for review. *Journal of Educational Psychology, 83*(2), 240-245.

Kirschner, P. A. (2002). Cognitive load theory: Implications of cognitive load theory on the design of learning. *Learning & Instruction*, 12(1): pp. 1-10.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, 63: pp. 81-97.

Nelson, B. C., & Erlandson, B. E. (2008). Managing cognitive load in educational multi-user virtual environments: reflection on design practice. *Educational Technology, Research, and Development*, Dec. 2008, 56: pp. 619-641.

Nelson, B., Ketelhut, D., Clarke, J., Bowman, C., & Dede, C. (2005). Design-based research strategies for developing a scientific inquiry curriculum in a multi-user virtual environment. *Educational Technology*, 45(1): pp. 21-27.

Paivio, A (1969). Mental Imagery in associative learning and memory. *Psychological Review, 76*(3), 241-263.

Paivio, A. (1986). *Mental representations*. New York: Oxford University Press.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12(2): pp. 257-285.