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LETTER FROM THE EDITORS

To our readers:

In this issue of The Learning Assistance Review we offer a range of ideas guaranteed to broaden the notion of what learning assistance is all about. The journal includes both theory and research as well as practical suggestions related to notetaking support, brain-compatible teaching strategies, redefining a learning center, and technology.

In the first article, Katayama and Crooks describe two experiments designed to offer insights into what kind of support structure is most helpful to students taking notes online. The authors provide a comprehensive overview of research done in this area and concrete examples from their work. They conclude with thought provoking questions for future implications.

Next, Rita Smilkstein explores the complexities of how the brain functions, and she offers a set of principles for teaching that is based on the "natural human learning process." Smilkstein provides a valuable integration of theory, research and practice as well as a synthesis of research from two areas of interest to educators, neuroscience and classroom experience.

From here we move into a description of how two learning center administrators met the challenge of having to redefine their academic skills lab. Stewart and Hartman detail the research process they conducted when they made the decision to rethink their learning assistance services. This article provides very practical information for all learning center professionals who find themselves in a climate of institutional change.

David Caverly's thoughts in *Join the Conversation* invite us all to share in the wonder and sometimes overwhelming implications of how technology is impacting our students. Along with this come some interesting implications of what this means for us as learning assistance practitioners. Finally, Judith Cohen reviews a book entitled, Using Student Teams in the Classroom that was recently highlighted in the Chronicle of Higher Education. With the increased use of learning communities throughout higher education, it is imperative that we all know how to best facilitate working with students in teams and how to assist students as they sometimes struggle to be effective team members.

Find some time to close your door and be stimulated by the range of new ideas waiting for you inside this issue.

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By Andrew D. Kata
Steven M. Crooks,

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ARTICLES

EXAMINING THE EFFECTS OF NOTETAKING FORMAT ON ACHIEVEMENT WHEN STUDENTS CONSTRUCT AND STUDY COMPUTERIZED NOTES

By Andrew D. Katayama, West Virginia University and
Steven M. Crooks, Texas Tech University

Abstract

Two experiments were conducted to investigate the effects of notetaking format on achievement while studying electronic text. In the first experiment, 83 undergraduates read over five text passages and were asked to construct and study one of three types of notes: partial (framework provided with about half of the notes provided), skeletal (framework provided with no notes provided), and control (no framework and no notes provided) on the computer. Two days later, students reviewed their notes and data were collected on posttest performance (fact, structure, and application tests). In Experiment 1, no significant differences were found between groups on the fact and structure tests; however, on the application test students who constructed partial notes significantly outperformed those in the control notes' condition. In the second experiment, 77 undergraduates studied either control or partial notes on the computer and a pair-wise comparison was conducted to detect differences between the two groups on structure and application tests one week later. No significant differences were found on the structure test, but once again on the application test, there was a significant difference found in favor of the partial notes format. The results of these studies suggest that when students take notes on the computer and then take application tests, they benefit most from partial notes.

Introduction

When students construct their own study notes to accompany text, they perform better than students who study notes provided by their instructor (Armbruster & Anderson, 1982; Kiewra, 1989; Russell, Caris, Harris, & Hendricson, 1983). It's conceivable that this effect can be magnified by providing students with an external framework for organizing their notetaking structures (Bernard, 1990; Kiewra, Dubois, Christian, & McShane, 1988). The activity of taking notes serves as an encoding function (DiVesta & Gray, 1972; Kiewra & Frank, 1988; Mayer, 1989; Peper & Mayer, 1978, 1986) in that information is "encoded" in a more permanent fashion rather than a temporary fashion, e.g., reading over instructor provided notes. Katayama and Robinson (1998) found favorable results for partially constructed notes (outlines and matrices alike) over completed notes (like ones distributed by instructors) on application tests. Crooks and Katayama (1998) found similar results in that students in the partial-matrix condition (i.e., those given row and column headings and about half of the notes) outperformed students in a control condition (i.e., those who constructed their own notes without any matrix framework) on structure tests (hierarchical relations).

The use of skeletal and partial outlines was found more beneficial than completed notes for medical students in a study by Russell et al (1983) because it allowed students to incorporate their own experiences and to elaborate the new information. In response to questionnaires, students responded that the skeletal notes were advantageous for review prior to the test and that they also encouraged students to concentrate on their own notetaking strategy within the provided guidelines. Furthermore, it was concluded that the quantity of information provided for students did make a difference on how students performed on tests and how much information they remembered as they completed their notes respectively. It was observed that the more students were involved in constructing their notes, the more information they remembered.

Similarly, the nature of the notes (linear or spatial) provided for students by the instructors can make a difference. Spatial displays and diagrams have undergone a great transformation as a result of their effectiveness on learning (Robinson, Katayama, & Fan, 1996). Knowledge maps are one type of spatial display that have been investigated by Dansereau and his colleagues (Hall, Dansereau, & Skaggs, 1992; Lambiotte & Dansereau, 1992; Rewey, Dansereau, Dees, Skaggs, & Pitre, 1992; Wallace, West, Ware, & Dansereau, 1998). These studies have investigated the instructional potential of providing students with spatial displays of text. A knowledge map is a node-link display that communicates relationships among ideas by using two-dimensional space. Generally speaking, these displays have been viewed as formal study notes that may accompany text. Appendix A presents an example of a knowledge map.

Other displays, such as matrix graphic organizers (two-dimensional notes) also contain a visual organization of the information while creating figures without a basic format (Winn & Holliday, 1982). Recently a few studies have explored how matrix organizers may be used when students study chapter-length text and are provided with multiple matrix organizers (Kiewra & DuBois, 1998; Robinson & Kiewra, 1995; Robinson, Katayama, Dubois, & DeVaney, 1998). Having students read and study the text and then review after a delay appears to be optimal for learning concept relations and applying those relations in new contexts (Zimmer, 1985). One constant belief has been that spatial notes differ from texts in that the logical or syntactical relationships that exist among the concepts are presented spatially on the page rather than in sentence form (Winn, 1980).

In the present study, we wanted to examine students' notetaking behaviors when studying a passage of text on the computer via the internet (different from Zimmer, 1985). We also hoped that this activity would enable students to benefit from recording their own matrix notes (encoding) without being overly challenged (as explained by Kiewra et al., 1988). Figure 1 presents an example of a matrix organizer of partial notes. Russell, Caris, Harris, and Hendricson (1983) previously found that paper-based skeletal and partial outlines were beneficial for medical students when taking paper-based tests. These benefits were also realized with partial-graphic organizers and partial outlines as students who constructed these types of notes outperformed students with a complete set of notes on application tests (Katayama & Robinson, 2000). One thing to consider about these past studies is that they all used hard copies of materials for students to work with. With this in mind, the authors of the present study wanted to see if they could realize similar results to Russell et al (1983) and Katayama and Robinson (2000) if the information were presented on the computer and students were required to study and construct their notes on the computer. Because computers are commonly accessible in just about every university setting, e.g., libraries, dorm rooms, classrooms, etc., this study would allow us to begin an exploration of how students study, take notes, and review their notes electronically before taking tests in a computer environment.

The hypothesis of the present study is to test whether any one of the three notetaking conditions (partial, skeletal, or control) would affect students' posttest performance on fact, structure, and application tests. Examples of each of these tests are found in the methodology section of this paper. Whether students read something from a screen versus hard copy doesn't seem to make a significant difference. We suspected that when students are given some note structure (like in the partial and skeletal-notes conditions), they will perform better than those students who have no structure on higher-order assessments such as structure and application. We hoped this activity would enable students to benefit from the activity of recording their own notes with some informational structure so that they would experience less learning difficulty (Sweller, 1994; Tuovinen & Sweller, 1999).

Experiment 1

Methodology

This study investigated the effects of three types of notetaking conditions (partial, skeletal, and control) on posttest performance (factual, structural, and application tests). The partial-notes condition provided students with a two dimensional framework (rows and columns), with approximately half the notes provided to them, and it required the students to key in the missing notes. Figure 1 presents an example of the partial-notes condition. The skeletal-notes condition only provided the students with the headings and categories for which they were expected to complete all the relevant notes. Figure 2 presents an example of the skeletal-notes condition. The control condition consisted of a blank screen for each text passage in which students could take whatever notes they wished (as they would in their "normal" study time). With the exception of the control condition (see Figure 3), the other conditions provided students with basic headings for conceptually organizing their notes. For example, column headings consisted of "definition" and "purpose," and row labels consisted of topics related to the content of the text passage.

Figure 1. Example of Partial-Notes Format

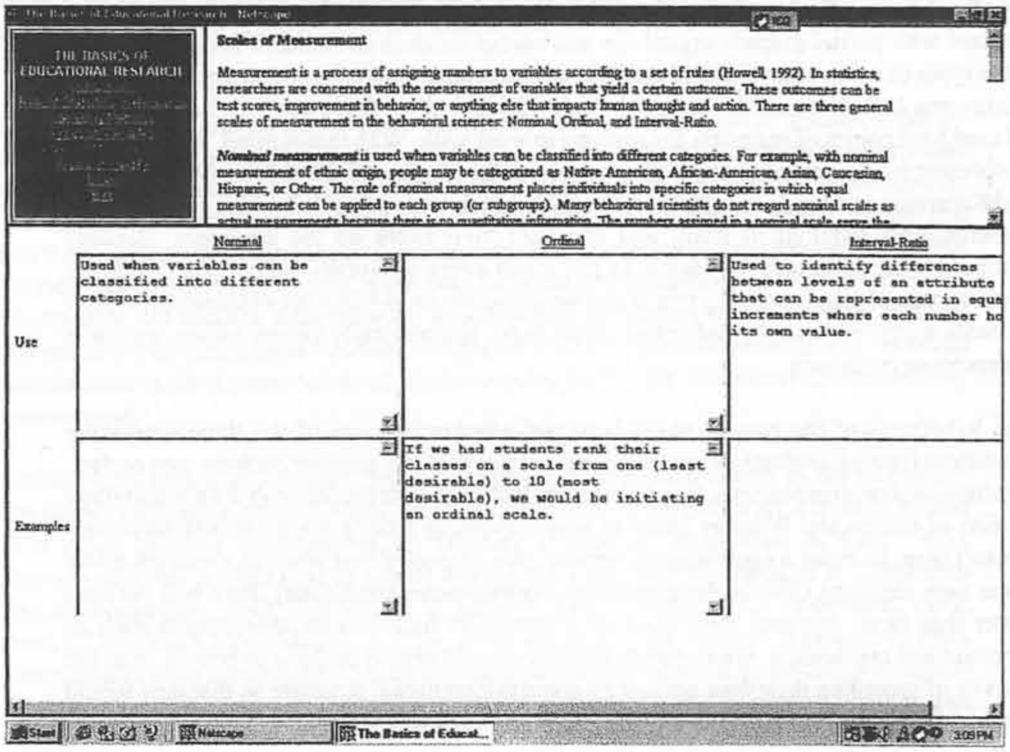


Figure 2. Example of Skeletal-Notes Format Used in Experiments 1 & 2

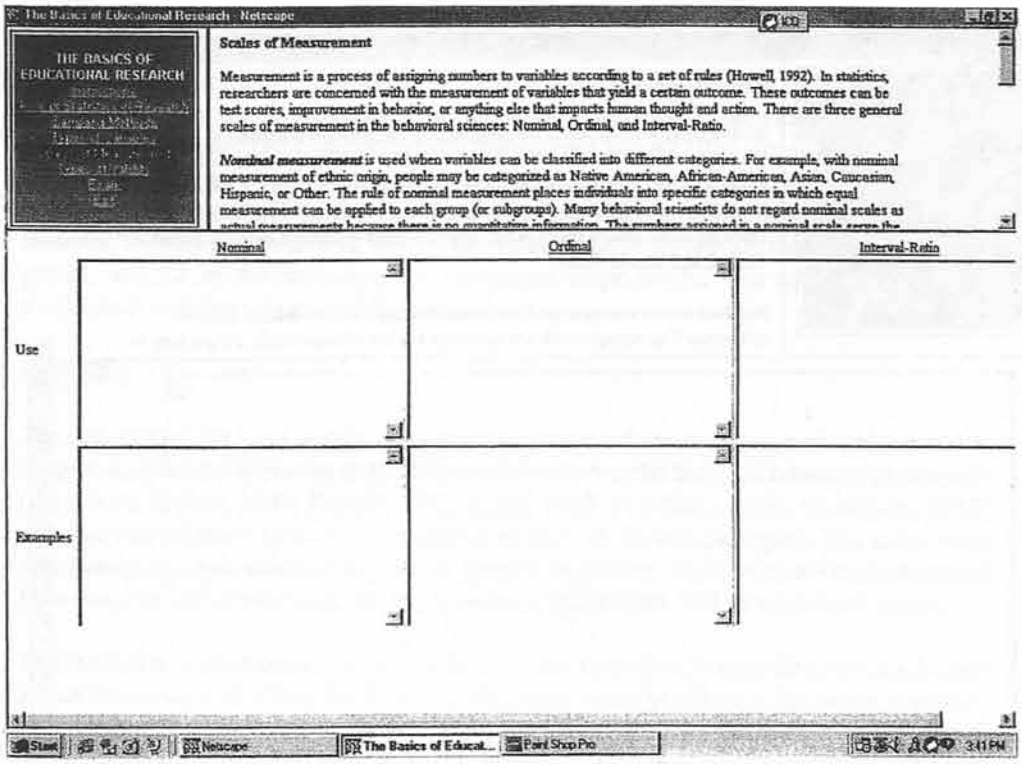
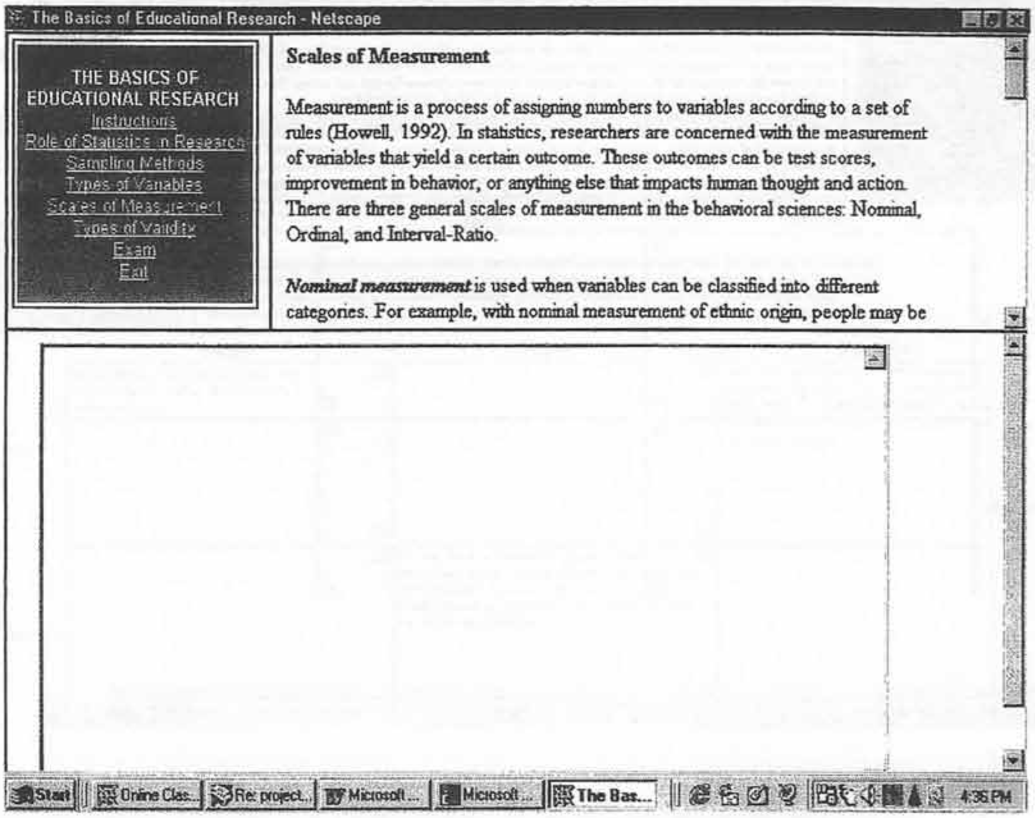


Figure 3. Example of Control-Notes Format



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A one-way design was used on the between-subjects factor of notetaking structure (partial vs. skeletal vs. control). For all three notetaking conditions, students were exposed to the text and notetaking options on the computer.

Participants

Eighty-three undergraduate students from three separate undergraduate educational psychology courses at a mid-sized state university in the Midwest voluntarily participated in this experiment for course credit. Due to computer input-error, data for 10 students were incomplete and therefore eliminated from the analysis (for all 10 students whose data were lost, an error in log-on protocol caused the program to re-assign a new condition that did not match their original notes, therefore making their data invalid). Of the remaining 73 students, 55 were female and 18 were male. There were 27 students in the control, 24 in the partial, and 22 in the skeletal-notes conditions respectively. The median age of the participants in this study was 21.5 years old.

Materials

The study materials used in this study were all presented online. They included a blended chapter-length text (approximately 3500 words) covering the basics of educational research (Gall, Borg & Gall, 1996; Howell, 1992; Kiess, 1989; McMillan, 1996; Shavelson, 1988) and five sets of study notes (corresponding to each of the text passages). The notes were represented in a two-dimensional matrix graphic organizer. Three tests were administered following the online studying: factual, structure, application, and an attitudinal survey.

The fact test was taken online and consisted of 15 multiple-choice items. Students could earn a maximum score of 15 on the fact test. The items were based on information explicitly stated in the text. The following is an example of an item on the fact test:

> A __________ is employed when all members of a defined population have already been placed on a list, and every tenth name is selected for the sample.
>
> a. linear systematic sampling method
> b. stratified random sampling method
> c. cluster sampling method
> d. random assignment method

Due to the nature of the structure and application tests, we were unable to format these tests online. The structure test was distributed as a hard copy test and consisted of 14 fill-in-the-blank items in which students had to recall the hierarchical structure of the text. The structure of each text passage contained a superordinate concept, i.e., Scales of Measurement, subordinate concepts, i.e., nominal scale, and coordinate concepts, i.e., nominal, ordinal, interval, ratio. In order for students to do well on the structure test, they needed to understand the hierarchy of the concepts within the text. Students could earn a maximum of 14 on the structure test. The following is an example of an item on the structure test:

> List three general scales of measurement used in the behavioral sciences.
>
> ________________ ________________ ________________

The application test was also distributed as a hard copy and consisted of 10 matching items in which students had to apply their understanding of educational research to novel situations (similar to Zimmer, 1985). Students could earn a maximum score of 10 on the application test. The following contains the directions and a sample item taken from the application test:

> Match the appropriate term by letter with each of the following scenarios. Note that each term may be used once, more than once, or not at all. Mark your answers in the space provided.

a.	Content validity	h.	Interval-Ratio scale
b.	Control variable	i.	Linear-systematic sample
c.	Dependent variable	j.	Nominal scale
d.	Descriptive statistics	k.	Predictive validity
e.	Face validity	l.	Predictive validity
f.	Independent variable	m.	Random Assignment
g.	Inferential statistics	n.	Stratified Sample

> ____ Dr. Freudsex has been collecting demographic data from his students for the past two years. His data set includes students' age, sex, year in school, major, and ethnicity. These variables are most likely to be analyzed using which type of scale?

An attitudinal survey was administered immediately following the tests. The survey consisted of 10 items to gather information about the students in the study. Four items consisted of self-reported demographic information, e.g., gender, major, class, gpa. Six items pertained to the students' attitudes, e.g., prior knowledge of the content, simplicity of completing the notes, preference for taking their notes on the computer, level of effort put into their notes, adequate time to complete the assignments in the two sessions, and helpfulness of notes when studying for the tests. These items were self-rated on a five-point Likert-scale where 1=Strongly Disagree (SD), 2=Disagree (D), 3=Neither Agree or Disagree (N), 4=Agree (A), and 5=Strongly Agree (SA). Appendix B presents the items included in the survey.

Procedure

This experiment consisted of two days of reading, notetaking, and reviewing before students engaged in the tests. On the first day, students were randomly assigned to one of the three notetaking conditions and were brought into the computer lab where they were asked to have a seat and await directions. Once all students were seated, the experimenters went over the directions and gave a brief demonstration of how to navigate through the text passages and notes fields (see Figures 1 and 2 for examples of text and notes fields). Students were told they would have approximately 45 minutes to complete and study their notes. They were instructed to go back and review their notes if they finished their tasks before the 45-minute time limit was up. Finally, students were asked to do their own work and to put forth their best effort during the 45-minute session. Students were dismissed at the end of the session and asked not to discuss the material with one another outside of class.

The second day of this experiment took place two days later for each of the three classes. The classes met in the same computer lab and were asked to sit at the same computer terminal as the first day. Students were asked to login using their ID numbers and their condition would automatically come up to the place where they had left off two days earlier. Students were asked to review and/or complete their notes for 15 minutes before taking the tests. At the end of the 15 minute review session, students were asked to click the "exam" button on their options window and to take the multiple choice fact test online. After approximately 10 minutes, all the students had finished the fact test and were asked to log-off their computers and to take out a pen or pencil to take the hard copy structure and application tests. The structure test took approximately five minutes to complete, and the application test took approximately 10 minutes to complete. Once those tests were completed, a 10-item attitudinal survey was administered and completed within five minutes at which time students were dismissed from the study.

Results and Discussion

Separate one-way analyses of variance (ANOVA) were conducted on the factual, structure, and application test scores. All tests were conducted at alpha = .05 level of significance. The assumption of homogeneity of variance was supported for the factual test, $\underline{F}(2, 69) = .375$, $\underline{p} = .689$, as well for the application test, $\underline{F}(2, 69) = 1.03$, $\underline{p} = .363$ according to Levene's $\underline{F}$-test of homogeneity. The assumption of homogeneity of variance was not supported for the structure test, $\underline{F}\ (2, 69) = 4.02$, $\underline{p} = .022$.

Table 1 presents the means and standard deviations for each of the groups on the three tests. The main effect of the notetaking condition (partial vs. skeletal vs. control) was not statistically significant on the factual test, $\underline{F}(2, 69) = 1.04$, $\underline{MSE} = 9.08$, $\underline{p} = .360$. This result indicates that the amount of information (partial, skeletal, or control) did not affect students' scores. Likewise for the structure test, the main effect of the notetaking condition was not statistically significant, $\underline{F}\ (2, 69) = 1.40$, $MSE = 11.53$, $\underline{p} = .254$. Because the structure test had a violation of homogeneity of variances, we conducted a non-parametric Kruskal-Wallis test on the structure scores which yielded a nonsignificant $\underline{H}$, $X^2\ (2) = .915$, $\underline{p} = .633$. However, on the application test, the main effect of notetaking condition was statistically significant, $\underline{F}$, $(2, 69) = 3.30$, $MSE = 20.78$, $\underline{p} = .043$. A Fisher's LSD was conducted to follow-up this effect ($\underline{SE} = .665$, $\underline{p} = .015$). Students in the partial-notes condition ($\underline{M} = 5.54$, $\underline{SD} = 2.24$) performed significantly better than those in the control condition ($\underline{M} = 3.77$, $\underline{SD}$

= 2.87) but not significantly better than students in the skeletal-notes condition (M = 4.22, SD = 2.30). There were no significant differences between the skeletal and control-note conditions. Table 1 presents the means and standard deviations for the three notetaking conditions for the different tests.

Table 1. Group Means and Standard Deviations for Experiment 1

	Fact Test		Structure Test		Application Test		
Condition	M	SD	M	SD	M	SD	N
Control	8.96	2.82	9.27	3.62	3.76	2.87	26
Partial	10.17	3.12	10.25	2.57	5.54	2.25	24
Skeletal	9.59	2.94	10.59	2.06	4.23	2.31	22

Conclusion

The purpose of this study was to investigate the relative effectiveness of three notetaking conditions (partial, skeletal, and control). Results indicated that partial notes were more effective than traditional notetaking strategies (our control condition) for helping college students apply knowledge from computerized text and notes. Therefore there appears to be a relationship between an active notetaking process and the application of text information. In particular, the partial notes seem to lend themselves best to the application of the concepts to novel situations. However, the results also indicate that there doesn't appear to be an effect for notetaking condition on learning text structure or facts.

In the present study, students who were provided with partial notes outperformed those who studied their own notes because they were better able to apply the information. One possible explanation for this result may be due to the two-day delay before the review session. We wondered how these results might differ if students were given longer between study sessions, i.e., notetaking session and review session. We also wondered how the results might differ if we shortened the review session and if the amount of notes the students keyed in was related to how they did on the tests.

Experiment 2

The researchers wanted to "tease" out the possibility that the results of Experiment 1 were due to a short delay between sessions (two days), so a second experiment was designed to test students after a one-week delay between notetaking and note reviewing and testing. Because we found no differences between the three notetaking groups on the factual test, we decided to concentrate our efforts on the structure and application tests. Therefore, the online fact test was not included in this second experiment. Also, we decided to narrow our focus to the two conditions in which we found differences in Experiment 1: control and partial notes. We also corrected the computer-input error from the first experiment.

Methodology

A pair-wise comparison was used because there were only two notetaking structures (partial vs. control), a between-subjects factor. For both notetaking conditions, students were exposed to the text and notetaking options via the computer. After a one-week delay between notetaking and note review, students were to complete two tests (structure and application). An additional variable of interest used in this experiment was the amount of notes taken for each text passage. The amount of information "keyed in" on each notes' screen was recorded in kilobytes (all keyed in characters). This did not include the column or row headings in the partial-notes condition. This programming feature allowed us to gather data about each student's notetaking in terms of quantity of notes. For example, a student's file that read 3.2 kb of notes would indicate that approximately 320 units of information were keyed in by that student for that particular screen of notes. In most cases, a single unit represented a single word or equivalent. The average "amount" of notes per page in this study was approximately 100 units (kb) per page.

Participants

Seventy-seven students from three undergraduate educational psychology courses at a mid-sized state university in the Midwest participated in this experiment. No students from study one participated in this study. Of the 77 new students, 48 were female and 18 were male. Eleven students did not specify their gender. There were 35 and 42 in the control and partial-notes conditions respectively. The median age of the participants in the study was 20.9 years old.

Procedure

The procedure for the first day of this experiment was the same as it was for the first experiment. The second day of this experiment took place one week after the first as opposed to two days later as in Experiment 1. Also, because we observed that 15 minutes was a bit long for the review session in the first study, we constricted the review time to ten minutes in this study. After the ten- minute review on the second day, students were presented with two tests and an attitudinal survey (same one used in Experiment 1). The structure test took approximately five minutes to complete; the application test took approximately ten minutes to complete; and the attitudinal survey took approximately three minutes to complete.

Materials

The study materials used in this second experiment were the same used in the first experiment with the exception of the skeletal-notes condition. The same passage of text was used in this experiment as well. Also, because no differences had been found on the factual test in previous studies (Crooks & Katayama, 1998; DuBois & Kiewra, 1989; Katayama & Robinson, 2000), we decided to eliminate this test for the second experiment. We attempted to program the structure and application tests online but were unsuccessful in doing so. Therefore, the structure and application tests were administered as hard copies just as they were in the first experiment.

Results and Discussion

An independent samples t-test was conducted on the structure and application tests. Both tests were conducted at alpha = .05 level of significance. Levene's test for equality of variances was supported for the structure test, F (75) = .175, p = .677 as well for the application test, F (75) = 1.82, p = .182. The main effect of the notetaking condition was not statistically significant on the structure test, t (75) = .081, MSE = 4.76, p = .94; however, on the application test, the main effect of the notetaking condition was statistically significant, t (75) = (-2.65), MSE = -1.17, p = .010. Students in the partial-notes condition (M = 6.40, SD = 2.06) performed significantly better than those in the control condition (M = 5.23, SD = 1.79. Table 2 presents the means and standard deviations for the groups on the structure and application tests respectively.

Table 2. Group Means and Standard Deviations for Experiment 2

	Structure Test		Application Test		
Condition	M	SD	M	SD	N
Control	9.57	2.51	5.22	1.78	35
Partial	9.52	2.59	6.40	2.06	42

Data from the attitudinal survey were analyzed for significant effects upon the two dependent measures and the amount of notes recorded by the program. The only worthy finding from this data set was that there was a statistically significant gender difference and the amount of notes taken for the control-notes condition, F (1, 62) = 395.21, MSE = 892.208, p = .032. The females took on average 5.00 kilobytes of notes (approximately five screens or pages of notes) compared to 4.44 kilobytes of notes by the males. The gender difference was less pronounced in the partial notes condition, F (1,62) = 9.17, MSE = 16.74, p = .077. Within the partial-notes condition, females took on average 3.73 kilobytes of notes; whereas, the males took 3.44 kilobytes of notes. This finding was only marginally different between genders, but the structure was provided in the partial notes condition so perhaps fewer notes were necessary within this note condition.

Conclusion

This study found that results between the two notetaking conditions were similar to the previous study. There were no significant differences between students in the partial or control-notetaking conditions based on their performance on the structure test. Therefore, based on the results from these experiments, we find that when students construct and study their notes and then are tested over text structure, there appears to be no advantage for notetaking condition (partial or control). But, once again, on the application test we found that students who completed and studied the partial notes significantly outperformed the students who constructed and studied their own notes in the control condition. This was the case in both experiments regardless of how long students had between sessions (two days or one week). Therefore it can be concluded that when we want students to apply what they have read, there seems to be an advantage of providing them with partial notes. Perhaps our findings are consistent with Peper and Mayer's studies (1978, 1986) where the encoding function of actually taking notes in an active manner allows for students to process the information at a deeper level, and it surfaces on the application test. Or perhaps the partial-notes condition helped students to guide their notetaking within this condition by providing examples. Further investigation of the "quality" of students' notes might provide greater depth into these quantitative findings.

Discussion

We firmly believe that notetaking in the partial-notes condition is an active process. Based on our findings, we believe there are better ways of providing notes for students than by simply giving them "our" notes or by allowing them to take notes without any structure or frames (particularly on the computer). Even though the control condition is an active process, the notes "frames" were absent. We have observed that students especially benefit from partial notes with higher-order test-taking, e.g., application items as the partial notes provide the structure and frames for students to take efficient notes. Therefore, in a practical educational setting, these results suggest that if teachers want students to simply learn facts or basic structures within a text, there may be no advantages among study note conditions. However, if teachers are interested in testing students' ability to apply their knowledge within a text, there are advantages among the conditions provided for students to take their notes.

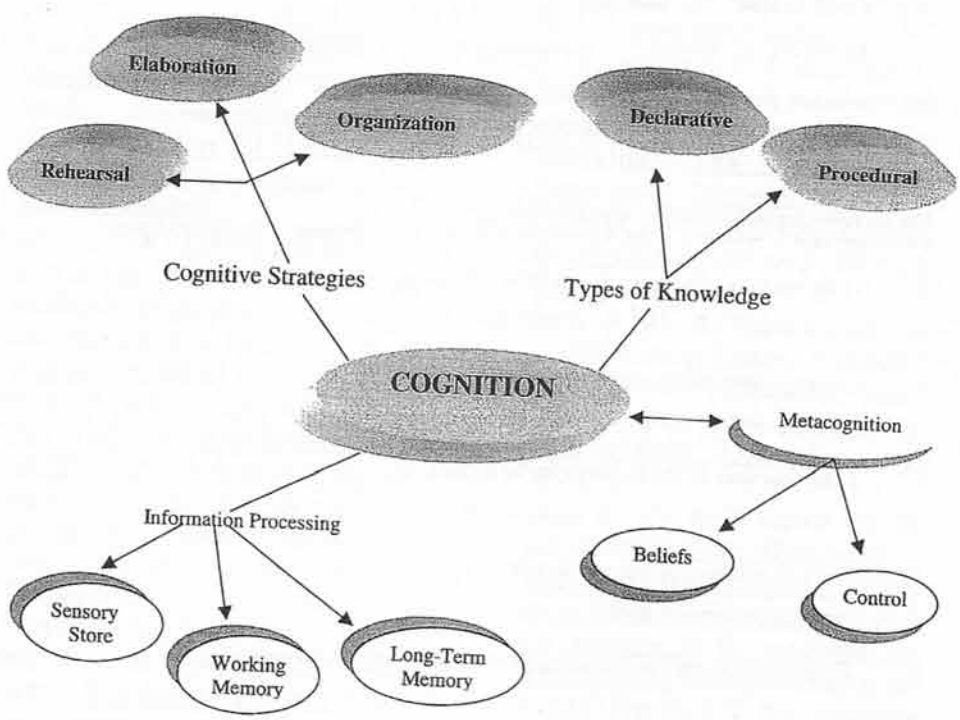
Recommendations for Future Studies

For future studies, we would like to investigate the notes themselves. For instance, we could divide the tests into two parts: items that cover information that is keyed in by the students vs. items that cover information in the notes provided. By examining this aspect of text application, we would be able to gain a clearer picture of the active notetaking processes purported by Peper and Mayer (1978, 1986). Based on the results of our second study, we would recommend that the gender differences be followed-up with respect to notetaking. Other questions of interest might include the following: How does electronic notetaking affect students? How do keyboarding skills (or lack of skills) interfere with notetaking and information processing? How does the presentation of information, color, font size, layout, amount of text presented, etc. contribute to students' ability to process textual information and construct sensible notes? And, when studying informationally-equivalent material, are there differences between studying electronic text and taking computerized notes and studying hard copy text and taking handwritten notes?

As with most of the studies cited in this paper, participants have been college learners who typically have effective notetaking and reviewing skills. Future research might investigate this design and methodology with less skilled and knowledgeable readers. Future studies may also want to consider different testing times (i.e., immediate vs. delayed) to investigate the effectiveness of notetaking conditions on longer-term memory of information keyed in on the computer. This variable might allow researchers to observe an interaction between notetaking conditions by testing conditions. Also, with the emergence of "electronic-learning," the partial-notes condition may prove to be an effective way for teachers to help students process information as well as to gather feedback from their students regarding their learning online. Finally, because there appear to be limited opportunities for students to construct information simultaneously with computerized text, the findings of the present study may lead to great benefits for online instructors and technology-enhanced courses by allowing students to take their notes online and perhaps to submit them back to the instructor.

Appendix A

Example of a Knowledge Map



Appendix B

Student Survey
Educational Psychology Project

Please circle one response for questions 1-4.

1. I am: a. Male b. Female

2. My major is: a. Education b. Non-education c. Undecided

3. I am a: a. Freshman b. Sophomore c. Junior d. Senior

4. My GPA is: a. 0-1.99 b. 2.0-2.9 c. 3.0-3.49 d. 3.5-4.0 e. not sure

Use the following scale to answer questions 5-10.
5 = Strongly agree 4 = Agree 3 = Neither agree or disagree 2 = Disagree 1 = Strongly Disagree

5. I have much previous knowledge about the topic before this study.

   5 4 3 2 1

6. I found the notes easy to complete study.

   5 4 3 2 1

7. I found the notes helpful for reviewing for the tests.

   5 4 3 2 1

8. I put a lot of effort into studying the notes.

   5 4 3 2 1

9. I would prefer to learn using a computer rather than a textbook for my classes.

   5 4 3 2 1

10. I had enough time to read and complete my notes.

   5 4 3 2 1

Andrew D. Katayan
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Steven M. Crooks, P
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HOW THE BRAIN LEARNS: RESEARCH, THEORY, AND APPLICATION

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Abstract

A human being is born with a brain innately impelled to think, learn, and remember. When educators understand the brain's natural process for performing these functions and apply this understanding in their work with students, they can better help students be the motivated, successful learners they were born to be. Neuroscientific research explains how the brain learns, and classroom research describes how students consciously experience their own learning. These two areas of research converge, leading to principles for developing brain-compatible learning activities for the successful learning of any subject at any level in the classroom or learning center.

Introduction

Some students aren't doing well in college. Perhaps one student has been placed in a pre-college developmental course and still isn't succeeding. Perhaps another has been out of school for ten years and is feeling overwhelmed and full of anxiety. Perhaps a different student is failing one or more courses. Perhaps yet another, a former dropout, starts the new term with high hopes and then gets ready to drop out again.

These students might come to the Learning Center for help. The learning assistance professional then ascertains why a student is not succeeding and how the student can best be served. Is the cause lack of motivation, too many outside responsibilities, lack of study skills, lack of prerequisite academic or subject-related concepts and skills, or a negative and self-sabotaging self-concept ("I'm stupid." "I can't do this.")? Or is something wrong with the student's brain functions? If the student does not have a learning disability or a brain impairment, there is probably nothing wrong with the student's brain and, consequently, it is working perfectly as his or her learning, thinking, and remembering organ.

Cardiologists, by knowing how the heart works, are able to help a patient's heart perform as perfectly as possible. By the same token, educators are better able to teach effectively when they know how the brain works. For example, an administrator at a community college at which faculty had participated in a workshop on brain-compatible teaching sent the author the following message:

> [A] computer faculty member said ... after [the workshop] that he did not believe in "that stuff." However, after thinking about what [he had learned], he

> restructured his summer class to [make it more brain-compatible]. He said it worked well beyond his expectations and that he had never gotten better student work or better student creativity. He's now sold on the idea of focusing on the [brain's natural learning process]. (J. Ball, personal communication, September 22, 1999)

The Human Brain and Learning

The brain is a physical organ in the body and, like any other organ, has evolved to perform specific functions, innately and naturally knowing what to do and how to do it. The brain has many functions from maintaining the body's temperature to regulating all the body systems. Of most importance to educators, however, are the three major functions of learning, thinking, and remembering.

The brain from birth has the ability to perform these functions because it is a natural pattern seeker. It is innately impelled—as the lungs are impelled to breathe and the heart to beat—to see, find, and make sense of patterns in the world and to form conceptual structures about them. Research shows that "babies are brilliantly intelligent learners" (Gopnik, Meltzoff, & Kuhl, 1999, p. 10, emphasis theirs). Bransford, Brown, and Cocking in their 1999 summary of education research, How People Learn: Brain, Mind, Experience, and School, report that five- to twelve-week-old infants are "capable of perceiving, knowing, and remembering [and] begin to grasp the complexities of their world" (p. 72) and that "[c]hildren lack knowledge and experience, but not reasoning ability. Although young children are inexperienced, they reason facilely with the knowledge they have" (p. xiv). Wynn (1992) finds that infants are even capable of doing mathematics. There is at present enough research to prove that human beings are indeed born as innate pattern detectors: "We now know that a newborn has a great many abilities and is predisposed to make order out of chaos.... Infants are outstanding pattern seekers" (Golinkoff, Mervis, & Hirsh-Pasek, 1994, p. 19; see also Freeman, 1995; Jensen, 1998; Mehler & Dupoux, 1994).

Human beings are also innate problem solvers reports Barrows (1994; with Tamblyn, 1980), a pioneer in Problem-Based Learning (PBL). The success of this instructional approach, which has been used in K-12 and undergraduate education as well as in medical education, derives from presenting students with problems to solve. It is the problem that stimulates the need to know, and, as he shows, human beings of whatever age are naturally motivated to solve problems. Healy (1994), in reviewing the research, reports the same findings: human beings are natural pattern-seekers, problem-solvers, thinkers, and learners from birth throughout life.

Witness the concentration, persistence, and motivation with which people of all ages play games. They are meeting challenges, solving problems, thinking critically, making discoveries, and seeking to learn more and more. "Look," a twelve-year-old middle-school student says, intent upon his electronic game, "they used to beat me at this level, but I figured out how to beat them and ... yes! Now I'm at the fifth level!" And on he goes, excited, energized, motivated to learn, learn, learn (Rome Davis, interview, February 2, 2000). This is the natural and innate impulsion of the human brain; any learner, of any age, whose brain is not impaired or does not sabotage itself with negative self-talk ("I don't belong here." "I can't do this." "I'm going to fail.") can learn just as eagerly, confidently, persistently, and with pleasure.

It is important to note, however, that the knowledge, skills, or concepts the brain acquires by means of its natural, innate learning process depends on the learner's experiences and environment. When human beings have the opportunity to experience activities and environments that are compatible with the brain's natural learning process, they learn naturally, successfully, and with motivation. On the other hand, some learning experiences and environments are not compatible with the brain's natural learning process of solving problems and seeking out patterns. Such an environment is the traditional classroom in which teachers lecture and demonstrate, and students take notes, observe, and memorize. Students who are well prepared with study skills and test-taking skills, have relevant prior knowledge, and have been socialized to behave appropriately (obediently and quietly) can perform successfully in such classrooms. While some of these students enjoy knowing what to do—and how to do it—to get good grades, other well-prepared students do not enjoy the exigencies of the traditional classroom. In any case, students who are not well prepared are always at a grave disadvantage (Heath, 1982, 1983).

Thus, when we see a student who does not have a brain impairment or who is not emotionally distressed but who, nevertheless, seems unable to learn, doesn't want to learn, isn't motivated to learn, or is apathetic or rebellious in school, we are seeing someone who is not enjoying his or her birthright to be a natural—and naturally motivated—learner. Outside school, of course, these students are learning, teaching themselves and each other, to be, among other things, electronic game, computer, internet, or web masters; sports experts; and popular culture savants. Furthermore, they do this challenging, complex learning and teaching with perseverance, confidence, enthusiasm, and intrinsic motivation.

Learning center professionals and classroom teachers are better able to help a student be as motivated and successful a learner in school as out of it when they understand how the brain learns and teach or work with students in a brain-compatible way. But how does the brain learn and what are brain-compatible ways of teaching and working with students?

How Learners Experience Their Own Learning

The author conducted research with over 5,000 participants, including students at all educational levels and faculty in disciplines across the curriculum. This research began when the author, then a community college basic skills English instructor, was working with students who did well on grammar worksheets but couldn't transfer that knowledge to their own writing. In frustration, she asked the students to think of something they had learned well outside school and then to write down how they had learned it, how they had gone from not knowing it or not knowing how to do it to knowing it well or being good at it. After they had finished writing, the author asked them to report on how they had learned, and she recorded verbatim their responses on the chalkboard. The students "called out a number of different things, including 'start basic' ... , and then the flurry of responses died down." The author asked them what happened next, and a second flurry began, including "'practice.'" After the students fell silent again, the author inquired whether that was the end or whether something else happened. The students responded with a "third flurry, including 'more practice,'" and stopped. As before, the author invited the students to say whether there was more. The students then volunteered a number of responses, including "'keep it going,' ... 'creative.'" Following this, a fifth flurry included "'improvement,'" and another pause ensued. Asked whether there was anything else, they called out their final responses, "'mastering it,' 'teaching it'" (Smilkstein, 1998, p. 55).

This sequence of stages, which is similar for every group, whether large or small, including, amazingly, a spontaneous pause after each stage, seems to constitute what might be seen as the natural human learning process (also see Kohlberg, 1981; Piaget, 1952, 1971, 1960/1981; Vygotsky, 1962, 1978). This research, which finds a four to six stage learning process (Smilkstein, 1989), converges with laboratory brain research (discussed in the next section), which shows the brain actually, physiologically learns in the same sequential, constructive, and connective process as seen in the natural-learning research. Data from three representative groups are presented in Table 1 below (Smilkstein, 1989).

Table 1. Stages of Learning (Responses recorded verbatim in three representative groups)

Basic Skills Community College Students	Instructors & Administrators Attending a National Conference Institute	Instructors in an On-Campus In-Service Workshop
Stage 1: Preparing to Learn Have an interest, know you like it, God-given talent, practice, start basic, creative (?). (All question marks signify that one person contributed this item but others disagreed.)	*Stage 1: Preparing to Learn* Desire, watching, experimenting (?), being shown and having it explained, practice, boredom, need, started with simple things, intuitive thing to do, looking for opportunities.	*Stage 1: Preparing to Learn* Trial & error, finding the problem, decide to do it, desire or need, motivation, observation, overcoming fear, lack of confidence, taught.
Stage 2: Starting to Learn Practice, practice, practice; get comfortable; be pushed by others.	*Stage 2: Starting to Learn* Watching, helping, trial and error, asking questions, purchased some resources, changed roles with a mentor or expert, teaching others (?), formally educated, reading books, curiosity, satisfaction, rewards inspired, practice and feedback.	*Stage 2: Starting to Learn* Trust someone to help out, instruction, practice, experiment, trial and error, feedback from others, need or desire to improve, give self feedback.

Basic Skills Community College Students	Instructors & Administrators Attending a National Conference Institute	Instructors in an On-Campus In-Service Workshop
Stage 3: Consolidation More practice, discipline, positive attitude, devotion, confidence, improving by adding new skills to it.	*Stage 3: Consolidation* Variations on a theme, pride in doing a good job, more opportunities to do it, recognition, take skill to higher level, do more difficult things, more responsibility, started to experience success and failures, record successes for others, teaching (?).	*Stage 3: Consolidation* Experience, demonstration, evaluating, more trial and error, taking risks, beginning to go solo, imitate, creativity (?).
Stage 4: Branching Out Keep it going, being inspired, being different from anyone else, branching out, creative.	*Stage 4-6: Branching Out, Gaining Fluency, and Continued Improvement* Experimenting, challenging yourself to find better ways, learning is ongoing, continue to learn more, more information, more difficult and more complex, exposing yourself to more things, evaluate more, reflection, understand I didn't know much, mastered it and teaching others.	*Stage 4: Branching Out* Refinement, confident, application, constant, go for it, deviate from what I've learned, creativity, spontaneity, improvisation, take risks, give self feedback.
Stage 5: Gaining Fluency Good challenge, not giving it up, pushing yourself to keep going so no burn out, high pay/ promotion, improvement, self-satisfaction evaluate progress so far.		*Stage 5-6: Gaining Fluency and Continued Improvement* Bridging, unique application, using skill as building block, automaticity, internalization, further refinement, teach others, creativity, seeing cosmic connections, stop doing it and lose some skill.
Stage 6: Continued Improvement Mastering it, teaching it.		

How the Brain Learns, Thinks, and Remembers

Brain research gives us a clear picture of what happens in the brain when human beings are learning. As, and because, people actively, personally experience, explore, interact with, practice, try to make sense of, think critically about, and use for their own purposes the object of interest (skill, concept, topic, body of information), specific physiological events naturally occur in the brain:

1. Some of the brain's 100 billion nerve cells (neurons) sprout branching fibers (axons and dendrites);

2. As these neural fibers grow, they make electrically and chemically activated connections (synapses) with other neurons and communicate, neuron to neuron, at these synapses; and

3. As this neural growth continues, ever-more neural pathways and synaptic connections are constructed until there is a complex network of connections between many neurons for that particular object of learning.

This is the physiology of learning. The neural networks themselves are, literally, the knowledge or skill that has been learned, and what the learner understands and can creatively and critically think about and apply.

The only exception is rote learning. If students are required to be only note-takers and memorizers of knowledge, successful rote learners will be able to remember the knowledge, but only as given to them, and will be able to use it, but only as instructed, shown, or explained to them. The neural networks for rote knowledge will be constructed and fixed in place through memorization or repetition. These rote networks are not flexibly and variously useable as are the neural networks constructed through the natural-learning activities of personal (learner-centered) experience, exploration, experimentation, practice, analysis, synthesis, evaluation, and creative application. With practice, rote knowledge can be used quickly and easily. The same is true of experientially constructed knowledge. However, experientially constructed knowledge, unlike rote knowledge, can be thoughtfully modified for use in different situations and becomes more refined, complex, and in-depth the more it is so used.

Chemicals and emotions also play key roles. First, thinking and remembering take place through communication between neurons at the synapses. Second, this communication is chemically activated. Third, emotions cause the body to produce either chemicals that facilitate synaptic communication or chemicals that prevent it. When chemicals produced by such emotions as fear or danger enter the brain, the brain goes into flight mode; thinking and remembering stop. For example, when a person is in a situation perceived as dangerous, certain chemicals instantly shoot into the brain and the brain stops thinking, i.e., stops problem solving, judging, deciding, strategizing. It shuts down synaptic communication so that the person can immediately, and without thinking, flee from the dangerous situation. This is what can happen when a student sits anxiously in class unable to understand the teacher or the work or when a student takes a test while filled with fear and negative emotions or self-talk ("I can't do this. I'm going to fail."). The student can't physically flee the classroom, but the brain is nevertheless effectively shut down. The synapses won't work: the fibers, synapses, and neural networks are still there, but the danger-activated emotions have caused flight-related chemicals to shut down the chemical-dependent synapses.

On the other hand, the body of a person who is experiencing the positive feelings of excitement, interest, and confidence produces chemicals that put the brain in the fight mode: ready for a challenge, focused, concentrating, experiencing positive emotions or self-talk ("I can do this."). Thus, this person's synapses receive doses of the chemicals that increase synaptic efficacy so that the person can think and remember more quickly and easily.

Furthermore, endorphins, the so-called pleasure hormones, are produced in the brain during successful learning. Thus, the brain not only is evolutionarily, innately impelled to learn, and has a natural, physiological process for learning, it also has an intrinsic motivation to learn: when we are learning, we feel pleasure.

To help students learn is to help them grow and connect their neural fibers and construct complex neural networks about each object of learning. The brain does all this physiological work on its own; however, we do not yet fully understand how the brain knows where and how to grow its neural structures. What we do know, based on the converging natural-learning research and brain research, is that each higher level of knowledge and skill is connected to, i.e., constructed on, a lower-level of knowledge and skill. What is actually happening is that more complex brain structures are being constructed on lower level, less complex brain structures. Lower levels or structures are prerequisite sine qua non foundations for higher ones (Fischbach, 1992; Jacobs, Schall, & Scheibel, 1993; Kandel & Hawkins, 1992; Milgram, MacLeod, & Petit, 1987; Petit & Markus, 1987; Smilkstein, 1993; Sylwester, 1993-1994, 1995). This physiological fact makes a constructivist approach essential for developing curriculum for the learning of any subject at any level.

Successful teaching practices based on this research show us what educators can do to help students learn, i.e., help them grow, connect, and construct their own increasingly complex brain structures of knowledge and skill. Most importantly, an educator cannot grow students' neural structures (cannot learn) for them; they can only help their students grow their own structures by providing students with opportunities for this growth, this learning.

> Emerging from all the data is a clear message. Each [learner] must build individual networks for thinking; this development comes from within, using outside stimuli as material for growth.... Explaining things to [learners] won't do the job; they must have a chance to experience, wonder, experiment, and act it out for themselves. (Healy, 1994, p. 39)

Several examples of constructivist curricula, which give students the opportunity to grow their own dendrites and neural networks, their own knowledge structures, are presented later in this article.

The Brain and the Learner

Brain research shows that learning, whether of social, cultural, aesthetic, physical, intellectual, or emotional phenomena, is nothing other than the growing and connecting of neural fibers and the constructing of neural networks; these physiological structures are the actual embodiment of a person's knowledge, skill, and beliefs both in and out of the classroom. For example, if a child is given to understand in his family that he is stupid (Father: "That was a stupid thing to do! You're always doing stupid things!"), the child's brain will grow neural structures that are that idea; and, as a result, the child knows and believes he is stupid. Neural structures increase in strength the more they are used. If the child over the years habitually thinks, whether as conscious self-talk ("I'm stupid") or as an unconscious sense that he is inadequate and inferior, he will behave that way. He will be and behave as he thinks he is, as his brain, his neural networks, knows he is.

Fortunately, however, these neural structures are alterable. When a person who believes she is stupid is told about her brain's natural learning process and that, therefore, she is a natural-born learner, and when this is proved by her actually beginning to experience some success, positive new brain structures can begin to grow. Additionally, the more she thinks the positive new thoughts and keeps experiencing even small successes, the more the positive new neural structures will grow and strengthen and the more ingrained and habitual the new self-belief will become. Similarly, the less she thinks the old thought, the less that negative neuronal structure is used, the more it will fade, the less she will believe it, and the less she will act on that belief.

The most difficult and frustrating case is the student with so-called fear of success, one whose neuronal self-identity structure is so strongly negative it interdicts the construction of a positive new structure. Such is often the case with a student who, on the brink of success, sabotages himself by being disruptive, not doing his work, cutting class, or even dropping out. The student with this level of self-sabotage often needs more than the expertise, positive feedback, and support of a classroom teacher or a learning assistance professional. This student may need psychological therapy. On the other hand, a student with so-called fear of failure starts growing a positive new self-identity structure when she begins to experience success.

Educators who imbue their work with knowledge of how the brain learns see that students, especially those who are used to failure and identify themselves as poor students, can experience success and grow positive self-identity structures. This is critical because a student's motivation can depend on whether, and to what degree, his self-identity structure, his view of himself, is positive or negative (Bandura, 1997; Bjorklund, 2000).

Brain-Compatible Curriculum and Learning Activities

Educators can better help students learn if they teach according to these principles of the natural human learning process:

1. Knowing about the brain's natural learning process can help an educator and the learner believe that every human being is born with a brain that needs to and is able to learn (limited, of course, to the extent of any impairment that might be

present). Some learners, of course, succeed more quickly and to a higher level of excellence than others due to a number of different variables, such as a specific aptitude, personality, or self-identity. Some of these variables are changeable while others (like aptitudes) are not.

2. People learn what they themselves work on, think about, talk about, and practice; it is essential to make mistakes, correct mistakes, learn from them, try again, and go forward one connected stage at a time. People learn what they practice because, while they are actively practicing, their brain cells are growing new neural networks, i.e., new knowledge structures. People need time to learn because they need time to grow and connect their neural fibers and construct more and more complex neural networks, i.e., higher and higher levels of knowledge and skill.

3. If learners do not have the neural foundation, i.e., the already acquired knowledge or experience, that the educator assumes they have, they will not be able to "catch on." Literally, physiologically, they do not have the prerequisite neural structure to which they can connect, and from which they can construct, the new, higher-level structure, i.e., new knowledge or skill. In other words, not having had the opportunity previously to construct the foundation neural network, they are neural-network disadvantaged and, thus, cannot help but falter; the new work will physiologically be "over their head," literally too far above or too distant from their neural structures for them to connect to it.

4. Because the brain can grow new networks only from the ones it already has, learners must first start a new object of learning by making a personal connection with something they already know or can do that is related to the new knowledge. They can then grow the higher-level structures from this foundation, constructing higher-level knowledge, level by level, stage by stage.

For example, as the first step in learning about historical timelines, students could create a timeline of major events in their own life. Then they could talk about the decisions they made when creating that timeline. By having made a personal connection between something they know and the new concept, they have created the all-important relevant foundation upon which higher level understanding of this new concept can now be constructed. Then, based on that personal understanding, in the next learning activity they would be able, and motivated, to thoughtfully discuss the challenges or problems a historian might face in trying to make sure a timeline about a historical figure is accurate. At the next higher level, they could think about the challenges or problems a historian might have in making an accurate timeline about a historical event or period. When learners are given the opportunity to construct new knowledge structures that start from where they are, they proceed with curiosity and interest, born of personal involvement, toward the understanding of a new concept far from where they were.

Some foundations, however, are not so easily and quickly constructed. Concepts and skills that are especially complex typically need a complex foundation. It might even take up to six learning activities, matching the six stages in Table 1, to construct such a foundation for higher-level understanding of that new complex concept or skill.

Several examples of natural-learning, brain-compatible curricula for constructing complex foundations are shown in Tables 2, 3, and 4. These curricula are based on the research discussed earlier and have been successfully used in college classes to introduce complex new concepts and skills. After experiencing these foundation-constructing sequences of activities, students are ready to progress to higher levels of understanding about each concept and skill.

These curricula are learner-centered and activity-based. As shown in the examples, they are implemented by a pedagogy which gives students opportunities to be as personally active and inter-active as possible. A high activity level is essential because the brain must be stimulated in order for it to grow new neural networks, i.e., new knowledge structures. In this pedagogical approach, students use a three-step cycle to do each learning task.

1. They think about or do the task individually; each student makes a connection with his or her own unique, idiosyncratic mindstore of relevant knowledge, each one having started where he or she is.

2. They bring their completed task to a small group of three to four and share, discuss, and even argue about their work.

3. Reconvened as a whole group, they discuss what they came up with in their small groups while the teacher writes their contributions verbatim on the board.

At the end of this debriefing, the collective knowledge of all the students is now known by every student about the concept or skill that was the subject of the task. The teacher can then proceed accordingly, targeting the next task to where the students are now after the task just concluded.

Table 2. Introduction to Fractions

	Stage 1 PREPARING TO LEARN: *Using current knowledge*	Stage 2 STARTING TO LEARN: *Experimental practice*	Stage 3 CONSOLIDATING NEW BASIS: *Skillful practice*
Individual	Teacher gives each student four 8x11 sheets of paper, each one a different color, e.g., white, blue, red, green: "Tear the blue sheet into two equal pieces and place them on the whole white sheet. Write down how you would tell or explain to someone how many of the blue pieces <u>one</u> of the blue pieces is."	"Now tear the red sheet into four equal pieces and place them on the white sheet. Write down how you would tell someone how many of the red pieces <u>one</u> of the red pieces is, then how many <u>two</u> of them are."	"Write down how you would tell someone how many of the red pieces <u>three</u> of the red pieces are, then how many <u>four</u> pieces are."
Small Groups	"Tell each other what you wrote down. Discuss what you were thinking when you were trying to figure out what to write."	As before.	As before.
Whole Group	"What did you write down? (Teacher writes all answers verbatim on the board.) What were you thinking when you were trying to figure out what to write?" (General discussion.) **Note: This is a complete cycle: Individual, Small Groups, Whole Group (I, SG, WG).**	"What did you write down?" (Teacher writes on board as before.) After the SG discussion at **Stage 2**, teacher writes 1----6 on the board and points to 1: "How many feel confused about what we're doing?" Then points to 6: "How many feel you understand what we're doing?" Repeats with 2-3 then 4-5. If most students are at 4-6, the Stage3 cycle can be processed more quickly.	"What did you write down?" Teacher writes all answers verbatim on the board as before. Then the teacher explains that these are called **fractions, which are parts of a whole (from the Latin word meaning "to break")** and they are written as 1/4, 2/4, 3/4, 4/4 (and that 4/4 = 1).

	Stage 4 BRANCHING OUT: *Knowing in more detail*	Stage 5 GAINING FLUENCY: *Using it, doing it*	Stage 6 CONTINUED IMPROVEMENT: *Wider application*
Individual	"Now tear the green sheet into eight equal pieces and place them on the white sheet. Write the fraction for <u>one</u> green piece. Then write a fraction for <u>two</u> green pieces, then for <u>three</u> pieces, then <u>four</u>, <u>five</u>, <u>six</u>, <u>seven</u>, and <u>eight</u> green pieces."	"Write down everything you know about fractions, including what the denominator and numerator tell us."	"Write six fractions for any different numbers of white, blue, red, and/or green pieces. You decide what different color pieces you will use and how many pieces you will have in each of your fractions."
Small Groups	As before.	As before.	"Show your fractions to each other. Discuss what your fractions, including the numerator and denominator, are telling other people."
Whole Group	"What did you write down?" Teacher writes all answers verbatim on the board as before—then gives the terminology: the top number is called the "numerator" and the bottom is called the "denominator."	"What did you write down?" Teacher writes answers verbatim on the board as before. General discussion with teacher explaining any student answer or idea that is not correct.	Some students write their fractions on the board. They discuss what these <u>fractions mean. General discussion.</u> If many students are still uncertain, do another Stage 6 cycle: "Write fractions for other numbers of pieces of different colors" (I, SG, WG).

Table 3. Introduction to Writing a Narrative

	Stage 1 PREPARING TO LEARN: *Using current knowledge*	Stage 2 STARTING TO LEARN: *Experimental practice*	Stage 3 CONSOLIDATING NEW BASIS: *Skillful practice*
Individual	Teacher says, "Write down what you did during the 30 minutes before class. You will have five minutes to do this."	"Go back in time from when class started to 30 minutes before, e.g., 'I sat down in my seat. Just before that I came into the room. A few minutes earlier I had been hurrying down the hall . . . .'"	"Now start at 15 minutes before class, go up to when class started, then jump back to 30 minutes before class started and work up to where you started (at 15 minutes before class.) But write as another person watching you: 'Jo walked up the stairs . . . .'"
Small Groups	"You have all written narratives, whether you know what narratives are or not! Read your narratives to each other and then, by looking at the similarities, come up with your definition of what a narrative is." (c.10 minutes)	"1) Read your new narratives to each other and amend your definition, if necessary. 2) What words/methods did you use now and in the 1st narrative to show the movement in time gong forward or backward?"	"1) Read and amend definition as before. 2) What transitions did you use to go back and forth in time? 3) Discuss the differences between writing about yourself and writing as someone else writing about you."
Whole Group	"What is your definition of a narrative?" (The teacher writes ALL points, verbatim, on the board and without comment. Any needed corrections will be made by the students themselves in the following stages—c. 10 minutes)	1) "Any changes that you want to make to the definition of a narrative?" (Teacher writes on board as before.) 2) "What words/methods did you use to show movement in time?" (On board.) These are called 'transitions.'" (Discussion)	1) "Changes to your definition? 2) "Transitions?" 3) "Differences between writing as 'I' and writing about 'Jo'?" (Discussion of 1st and 3rd person points of view. Teacher asks some students to read their narratives.)

	Stage 4 BRANCHING OUT: *Knowing in more detail*	Stage 5 GAINING FLUENCY: *Using it, doing it*	Stage 6 CONTINUED IMPROVEMENT: *Wider application*
Individual	(Teacher assigns reading of a narrative in text.) "Write notes about the author's time sequence and use of transitions. What is the point of view? Is it a narrative? Use your definition to answer this question."	"Write a narrative of your own choice on one of your own experiences. Write in your choice of 1st or 3rd person. Use transitions to help your readers follow your movement through time backwards and/or forwards." (Probably as homework.)	"Revise your narrative or write another one. You might want to try a different point of view and/or different time sequence." (Probably as homework.)
Small Groups	"Share and discuss your notes. Point to specific places in the text to show what you have seen."	1) "Read your narratives to each other. Listeners tell what you heard and understood. Discuss transitions and point of view. Give ideas for improvements." 2) "Did you have any problems or questions when writing?" 3) "What makes a good narrative?"	"1) Read and give feedback. 2) Discuss problems/questions you had when writing. 3) Discuss ways to improve writing narratives."
Whole Group	What did you come up with? (Teacher writes answers on the board as before.) Stage 4 can be repeated so that students can see the range of narratives. Teacher can now lecture if necessary.	1) What did you learn from the group feedback? 2) What are your problems and questions? 3) What you know about writing narratives and what makes a good narrative? 4) What can you do to improve your writing of a narrative?	"What did you come up with?" (Group discussion; teacher writes their points verbatim on the board.) Students hand in for teacher evaluation and, when returned, do further revisions.

Table 4. Anthropology 100: Introduction to a Desert Tribe

	Stage 1 PREPARING TO LEARN: *Using current knowledge*	Stage 2 STARTING TO LEARN: *Experimental practice*	Stage 3 CONSOLIDATING NEW BASIS: *Skillful practice*
Individual	The teacher says, "Make a list of everything you need to survive."	Showing a map of the Sahara Desert, the teacher says, "You live here. Now make a list of everything you need to survive."	The teacher says, "People have lived here for thousands of years. What do you think they need in order to survive?"
Small Groups	"Share your lists and discuss your survival needs."	"Share your lists and discuss your survival needs here."	"Share your lists and discuss what they need in order to survive."
Whole Group	The teacher asks, "What did you come up with?" (The teacher transcribes on the board verbatim whatever the students contribute.)	The teacher asks, "What did you come up with?" (The teacher transcribes on the board verbatim whatever the students contribute.)	The teacher asks, "What did you come up with?" (The teacher transcribes on the board verbatim whatever the students contribute.)

	Stage 4 BRANCHING OUT: *Knowing in more detail*	Stage 5 GAINING FLUENCY *Using it, doing it*	Stage 6 CONTINUED IMPROVEMENT: *Wider application*
Individual	(The teacher shows a film of the tribe.) "Write down what you saw about their life and what they do to survive."	"Write down everything you now know about this tribe and what it does to survive."	The teacher gives an exam. AND/OR Students are assigned to rewrite their individual papers about how the tribe survives.
Small Groups	"Discuss what you saw and whether it is similar to or different from what you thought they would be doing."	"Share and discuss what you wrote." AND/OR "Together, collaboratively write a group paper about the tribe."	"Review and correct your exams together." AND/OR "Share and discuss your revisions or work together on your group paper."
Whole Group	The teacher asks, "What did you come up with?" (The teacher transcribes on the board verbatim what the students contribute and adds more in a lecture--if necessary.)	The teacher asks, "What did you come up with?" (The teacher transcribes on the board verbatim what the students contribute AND/OR students read their group papers with class discussion.)	The teacher asks, "What did you come up with?" (The teacher discusses/ responds to students' test answers AND/OR students read their group papers with class discussion.)

Implications

Brain-compatible teaching gives all students the opportunity to use the brain's natural and innate connective, constructive learning process. As a result, students' brain structures will naturally grow and students will naturally learn. When educators understand the brain's natural learning process, they are able to develop and implement brain-compatible curricula and learning activities for both the classroom and the learning center. In this way, educators are better able to help their students be the critical thinking, motivated, successful learners they were born to be.

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