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ABSTRACT

This study was undertaken to determine whether convergent or divergent computer software better enhances children's critical and creative thinking skills. Subjects were 40 elementary students (4th, 5th, and 6th grades), who were randomly assigned to either convergent or divergent software treatment. These students interacted for 25 hours with numerous software packages designed to encourage the thinking skills of their treatment. Three tests were then administered: Schaefer's Creative Attitude Survey, the Torrance Tests of Creative Thinking, and the Cornell Critical Thinking Test. As hypothesized, subjects in the divergent group scored higher than the convergent group on all 14 measures within the creative thinking test. However, only one of the 14 comparisons was at a significant level. No differences were found on either the critical thinking test or the creative attitude survey. A listing of packages used by each group and a table displaying statistical data are appended. (24 references) (Author/EW)

The Effects of Convergent and Divergent Computer Software on Children's Critical and Creative Thinking

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Running Head: CONVERGENT/DIVERGENT SOFTWARE

Abstract

Although there have been many claims regarding the cognitive and creative benefits of computer software, research results are conflicting. Thus, the intent of the present research project was to evaluate the usefulness of computer software in enhancing children's thinking skills. In this experiment, forty 4th, 5th, and 6th-grade students were randomly assigned to either a convergent software treatment or a divergent software treatment. Subjects then interacted for 25 hours with numerous software packages designed to encourage the thinking skills of their treatment. At the end of the treatment period, three thinking skill tests were administered. As hypothesized, subjects in the divergent group scored higher than the convergent group on all fourteen measures within the creative thinking test. However, only one of these fourteen comparisons was at a significant level. No differences were found on either the critical thinking test or the creative attitude survey.

The Effects of Convergent and Divergent Computer Software on Children's Critical and Creative Thinking

The major research question to be addressed in this paper is whether available and highly advertised educational software is effective in teaching higher-order thinking skills. Specifically, can children in grades 4-6 be taught to think more creatively or more critically from exposure to problem solving software and tools?

Because a multitude of recent software has emphasized problem solving skills, there is a great need for careful evaluations (Patterson and Smith, 1985). Further impetus for this proposed study comes from conflicting results of investigations that have been done to assess and verify the creative and cognitive benefits of such software. Surprisingly, there is a lack of research to support all of the problem-solving development underway.

Problem solving software must encourage divergent thought as well as logical thought, thereby preparing students for the varied intellectual demands that will be made upon them during their lifetimes. Divergent thought has been defined as "the ability to bring something new into existence" (Barron, cited in Davis, 1986). Perkins (1987) notes that there are three ways of defining creativity, namely, 1. Potencies--basic mental operations or cognitive skills, 2. Patterns--how basic mental operations are organized and configured, 3. Values--criteria by which one selects goals, methods, and solutions.

Students must also engage in powerful critical thinking to become contributing members of an information based society. Presseisen's review of critical thinking for the 1986 annual meeting of the American Educational Research Association (AERA) detailed reasons for the revival in thinking skills. She also included a summary of the popular critical thinking definitions appearing since the 1940's. Listed below are just two of these definitions: (Both cited in Presseisen, 1986).

> Critical thinking calls for a persistent effort to examine any belief or supposed form of knowledge in the light of evidence that supports it and the further conclusions to which it tends (Glaser, 1941).

> Critical thinking is reflective and reasonable thinking that is focused on deciding what to believe or do (Ennis, 1985).

In effect, critical thinking includes defining a problem, selecting pertinent information, recognizing stated and unstated assumptions, formulating and selecting relevant hypotheses, and detecting bias in statements (Presseisen, 1986). According to the Presseisen article, critical thinking is composed of a mix of dispositions, abilities, strategies, and patterns.

Apparently, creativity and critical thinking differ in their directionality more than anything else (Perkins, 1987). Critical thinking aims to produce an assessment of things, beliefs, and courses of action, while creativity aims to produce an original product. There is an overlap between the two since creative thinking involves innumerable episodes of evaluating solutions and critical thinking depends on inventions and ways of breaking one's mental set.

Tisone and Wismar (1985) propose that the use of a microcomputer in an educational environment will enhance student "problem solving, divergent and convergent thinking, motivation, and cognitive and affective domain abilities." Through student self-selection, computer interactivity, immediate feedback, tireless patience, branching, randomization, networking, privacy, and possibilities for multiple solutions, the computer will tend to promote both risk-taking and the evaluation of one's risky decisions (Tisone and Wismar, 1985). When the computer can offer opportunities where it is accepting of all student responses, then it will promote guessing, brainstorming, and the development of one's own problem statements. However, it should also allow for one's brainstorming alternatives to be systematically narrowed in discovering the best idea that solves the problem.

Most commonly available problem solving software and tools can be divided into two main categories: 1. convergent software and 2. divergent software.

In convergent software the problem solution tends to be well-defined or discrete and it can be evaluated by the computer (Steffin, 1983). Convergent thinking is emphasized in the majority of educational software in which the learner eventually focuses on the best idea to adequately solve the problem (Tisone & Wismar, 1985). The answer exists somewhere within the programming code, awaiting student discovery. Convergent problem solving software often incorporates links to prior learning, examples and nonexamples, and comparisons and contrasts with other concepts. Here, the learner is asked to combine or recombine rules recently learned into the solution strategy of a similar problem.

In contrast, divergent software incorporates a flexible environment where students can select and experiment with new ideas (Gallini, 1983). Problem solutions are not well-structured, creating original design opportunities for the student. Due to this uniqueness, the computer will probably be unable to evaluate student answers. Not surprisingly, divergent software is accepting of almost all of the student's responses. (Tisone & Wismar, 1985). When there are "correct" responses these appear to be extremely large or unlimited. The software in this category is scarce and most of what is presently promoted as divergent software is questionable in both theory and practical use.

Several questions arise when considering the interaction between computers and the teaching of critical and creative thinking.

1. Can students be taught higher-order thinking skills through computer software?

2. What are some examples of attempting to use the computer to teach these thinking skills? How successful have these projects been?

3. Can students be expected to attain critical or creative attitudes and awareness through a brief training program? And if so, does this transfer to other activities?

Many investigators have examined the instructional effectiveness of educational software. Stearns (1986) reported that problem solving skills can be taught to learning disabled students and suggests that the computer will continue to motivate them as long as a variety of challenging software is provided. Parker, Barry, and Exner (1984) found that approximately 70% of the students in grades 4-6 prefer problem solving software to programs designed for drill and practice. Guckenberg (1987) notes that the most popular features of good educational software appear to be color, sound, quality of directions, challenge, fantasy, curiosity, and learner control over pacing, goals, and difficulty level.

During the past few years a multitude of problem solving packages have been produced by designers who are concerned with the skills that are being taught to the user.

Sunburst has used a problem solving matrix to design a series of programs that teachers can use in addressing designated skills. The formation and use of this and other matrices indicates that some companies have begun to consider exactly what type of benefits students will receive from exposure to their packages.

The increase in software designed to teach thinking skills suggests that there may now exist a way to teach skills that were impossible to teach effectively before computers (van Deusen & Donham, 1986/87). However, many researchers caution against seating children at computers and expecting them to learn from even the best software without providing them with direct instruction in thinking skills (Pea, Kurland, & Hawkins, 1985; Smith, 1987; Stearns, 1986).

There are four types of computer related thinking skill instruction currently being performed. Some researchers have used computers to enhance specific components of thinking (the structure of intellect approach), a few others have emphasized thinking for its own sake (the Bloom approach), still others try to link available software to content in a practical way, and finally, one program has tried to decontextualize common application packages and instead emphasize an information processing theory of instruction (Pogrow, 1987). Due to time constraints, a combination of the first two approaches was used in this study. Examples of only the first, second, and fourth approaches will be reviewed below, since the ways in which educators have linked software to specific content areas (Approach #3) are too varied to mention here.

1. The Structure of Intellect Approach. There have been a number of attempts to teach specific aspects of critical thinking using computer application packages. Bass and Perkins (1984) successfully taught critical thinking skills (verbal analogies and deductive reasoning) to seventh-graders, using packages like Rocky's Boots, Inference and Prediction, Analogies, Critical Reading, and Snooper Troops. Woods (cited in Sadowski, 1984/85) used a minicomputer program to improve the critical thinking skills of college students. In an attempt to replicate the Woods study with younger students, Sadowski (1984/85) found no significant gains in critical thinking.

The creativity camp has received support from two recent studies enhancing divergent thinking skills through exposure to the Logo programming language (Clements & Gullo, 1984; Clements, 1986). In the first study, Clements and Gullo (1984) taught Logo programming to 6-year-olds who later scored significantly higher than a computer-assisted instruction control group in creative fluency and originality. In a follow-up study, Clements (1986) demonstrated again that creativity (this time originality and elaboration) can be strengthened through Logo. In another creativity related experiment, Miller and Kapel (1985) discovered problem solving and simulation software had a positive effect on students' spatial discrimination and visual rotation skills, as measured by the Wheatley Spatial Abilities Test.

2. The Bloom Approach. One popular educational package mentioned in the prior section, Logo, a programming language designed for children, has often been promoted to "teach thinking for the sake of thinking." Recent studies with Logo have produced conflicting results. One study failed to substantiate any association between Logo programming and the subsequent development of planning skills (Pea, Kurland, and Hawkins, 1985). Later, an eight-month study in Logo enhanced the development or application of problem solving skills in children in a variety of problem solving contexts (Smith, 1987). The positive results occurred when students were given repeated and explicit examples of the applications of the problem solving methods.

4. Information Processing Theory Approach. Pogrow's HOTS program uses a lab of 15 computers and commercially available software to teach analysis, synthesis, constructing sophisticated associations between ideas, and associating apparently disparate facts (Pogrow, 1987). HOTS

is an intense two year program set up for Chapter I students in grades 4-6 and for gifted students in grades 1-2. Instead of Computer Assisted Instruction (CAI) environments, children in the HOTS program work in Computer Involved Environments (CIE). CIE's are organized around Socratic techniques, most evident in teacher-student dialogues and incomplete teaching practices. The teacher employing this program is more of a guide or coach than a director. Dialogues with students before computer time regarding the similarities and differences of the concepts in the software packages is an attempt to get students involved in the process of working with ideas.

In summary, although there have been a number of computer related studies generated, there is still inadequate evidence that computer software does, in fact, stimulate higher-order thinking. Streibel and Garhart (1985) argue that these require a lot of time, interpersonal dialogue, expert guidance, and repeated practice to develop. Patterson and Smith (1985) add that while there are programs that are successful in teaching students specific problem solving heuristics within the limited environment of that particular program, they cannot find any quantitative evidence that strategies learned from these packages transfer to more complex and less structured problems.

The majority of the research described above used a cooperative learning design to give students more responsibility for contributing to each other's learning (Miller & Kapel, 1985; Smith, 1987; van Deusen & Donham, 1986/87). Not only is this a more efficient use of limited hardware and software, but students who become frustrated at any particular stage in the problem solving process also have a chance to discuss, debug, and clarify that situation with their peers (Johnson & Johnson 1986). Computer-aided cooperative learning (CACL) maximizes the advantages of both computers (feedback, reinforcement, and keeping students on task) and cooperative learning (modeled strategies, greater discussion of thoughts, and an increased evaluation of ideas). It is not clear from this research, however, whether either convergent or divergent thinking skills would benefit more than the other in this type of environment. It may depend upon the actual application that is made with a particular software package.

The studies reviewed indicate that there is potential for expanding convergent and divergent thinking in learners using computer-assisted instruction (CAI) software. At the same time, in the Clements (1986) study Logo was found to increase creativity while computer-assisted instruction packages did not. The packages selected were not intended to increase performance in creativity. Thus, the use of CAI packages to increase creativity remains an open topic.

This study was designed to assess the effects of divergent and convergent CAI packages on creativity (group one) and critical thinking (group two), respectively. The following hypotheses were tested:

<u>H1.</u> Group one (divergent group) will score significantly higher than group two (convergent group) on a creativity test which yields scores for fluency, flexibility, originality, and elaboration.

<u>H2.</u> Group two will score significantly higher than group one on a test of critical thinking which yields scores for induction, deduction, credibility of sources, and assumption identification.

<u>H3.</u> Group one will score significantly higher than group two on a creative attitude survey.

The Method

Subjects

The subjects were forty 4th, 5th, and 6th grade children from the Belleville, Lake Mills, Lodi, and Ripon School districts in Wisconsin. Subjects voluntarily signed up for a summer course entitled Thinking Skills and the Computer. Students were randomly assigned to one of two treatment groups on the first day of class.

Materials - Hardware and Software

All of the schools used Apple computers. The students worked in pairs in order to make the study comparable to most current research and to take advantage of a cooperative learning environment.

Packages were selected based on possible convergent or divergent use, ease of use, publication data, age, novelty, recommended age level, and company description. At the time of selection, packages related to brainstorming, designing patterns, drawing and animating pictures, and writing stories, poems, and music seemed to offer the most divergent paths and the greatest potential for facilitating creative attitudes and awareness. In contrast, convergent thinking packages typically required the learner to look for supporting evidence, detect bias in statements, formulate and select appropriate hypotheses, and/or draw conclusions.

Bearly Limited, Broderbund, Compu-Teach, DLM, The Learning Company, Midwest Publications, Mindscape, Scholastic, Spinnaker, Springboard, and Sunburst Communications were contacted regarding loaner software packages for the study. They sent the packages in Table 1.

Insert Table 1 about here

Testing Instruments

Schaefer's Creativity Attitude Survey (CAS) was used because it tests for a creative attitude or disposition noted earlier as a key component of the creative person.

This instrument was developed for the exact age group of the study, grades 4-6. Students were given unlimited time to answer the 32 questions of the survey. This test is not widely used, even though it has adequate test-retest reliability of .61 (Schaefer, 1971).

The main test used to measure creativity was the Torrance Tests of Creative Thinking. This instrument tests students' ability to think creatively with words and pictures. Thinking creatively with words included two activities from the Verbal Booklet Form A: Activity 5, Unusual Uses, and Activity 6, Unusual Questions. Thinking creatively with pictures were drawn from the Figural Booklet Form A: Activity 2, Picture Completion, and Activity 3, Lines. During the test administration the instructor read the instructions as they appeared on the test booklet, allowing ten minutes for completion of each activity. The Torrance Tests were scored for fluency--number of ideas; flexibility--number of different types or categories of ideas; originality--how unique an idea is when compared to a normative group; and elaboration--number of details added to the main idea. The test-retest reliability coefficients are in a satisfactory .60 to .90 range (Torrance, 1974).

The Cornell Critical Thinking Test (Form X) was the second major test of the study. This test was originally developed for adults during the 1960's by Robert Ennis at the University of Illinois. Level "X" was later developed for grades 4-12 and examines four major areas of critical thinking: induction, deduction, credibility of sources, and assumption identification. As specified in the test manual, students were allowed 20 minutes for the first two parts, and twelve minutes for each of the last two parts. Test-retest reliability estimates for Level X range from .67 to .90 (Ennis, Millman, and Tomko, 1985).

Procedure

At the beginning of each day, the students chose partners from their respective groups and together selected at least one package to work with for that day. Students were asked to alternate roles between decision-maker and keyboarder so they would have opportunities to both generate and input/evaluate ideas. The teacher provided limited answers to students to encourage them to think about each package on their own. By the end of the course, students had worked with every package from their group at least once. At that time, they were given the Schaefer, Torrance, and Cornell Tests, respectively.

Analyses

Analyses of the test scores was as straightforward as possible. The two experimental group score means on each test and subtest were compared to one another using t-tests with an alpha protection level set at a .05, with 38 degrees of freedom. As per the original hypothesis, any comparison to the control group was a one-tailed test since it was assumed that the experimental group would always score higher.

Results

Test Scores

Both the Schaefer Creative Attitude Survey and the Cornell Critical Thinking Test were computer scored by the Testing and Evaluation Services Department at the University of Wisconsin - School of Education. The Torrance Tests of Creativity were scored by a gifted and talented coordinator who had been using and scoring them for over ten years.

To determine if there were any significant differences in mean scores between the two groups, a series of *t*-tests were performed on each test and subtest. Means, standard deviations, differences in means, and *t* scores for all three tests and corresponding subtests are presented in Table 2.

Insert Table 2 about here

Analyses showed no significant differences between the two groups on Schaefer's CAS. The convergent software group scored slightly higher on this attitudinal measure. Additional breakdowns by grade level also failed to show significant differences. There were no subtests for this instrument.

Fourteen separate *t* scores were performed on the results of the Torrance tests. The divergent software group did score higher on every component of the Torrance tests. Larger differences in means were observed on the figural subtests than on the verbal subtests. However, the only comparison that revealed a significant difference between the two groups was figural fluency, $t_{38} = 2.15$, $p < .02$. This score was an indication of the number of additional pictures completed by the divergent group. No other score was significant.

The statistical approach for the *Cornell Critical Thinking Test* was basically the same, except that the opposite group (group 1--the divergent software group) served as the control group. Analyses showed no significant differences between the two groups.

Unexpectedly, the divergent software group scored higher than the convergent software group on assumption identification. As noted in the Table 2, the *t* score of -2.15 for assumption identification was not considered significant due to the directional nature of the original hypothesis. Furthermore, according to Robert Ennis, the assumption identification subtest lacks statistical validity (Ennis, Millman, & Tomko, 1985). Ennis has claimed that the small number of items (10), the overlap with other subtests, and the difficulty of measuring this aspect of critical thinking have caused this portion of the test to be of questionable validity. Thus, no confidence was placed on this measure.

As a whole, verbal feedback from students indicated that working in cooperative groups was beneficial. Knowledge intensive packages (e.g., Where in the World is Carmen Sandiego? and Think Quick) and those that refer to more than one person by name (e.g., Reading Between the Lines and The Incredible Laboratory) were better suited for paired learning than some of the more individualized printing packages (e.g., Print Shop and Certificate Maker). Apparently, knowledge intensive packages required the students to pool their prior knowledge and also become individual experts at certain components of the package, creating numerous situations that called for cooperation.

Discussion

The results suggest that intensive exposure to educational software may promote creative thinking skills. Analyses revealed a significant difference in the figural fluency component of the Torrance Tests of Creative Thinking. Children in the divergent group may have increased their ability to produce larger numbers of creative ideas as compared to the control children because interaction with the divergent software packages facilitated creative thinking within a figural context.

The emphasis on figural thinking within the study's divergent treatment (e.g., Animate, Dazzle Draw, Drawing Board, Facemaker, PatternMaker, and Rainbow Painter) may have accounted for the higher scores on the figural fluency subtest. Students used these packages repeatedly and protested when they had to move on to something else.

Verbal skills were promoted by a number of divergent thinking packages (e.g., Certificate Maker, Creative Thinking and Problem Solving, Kid Writer, Newsroom, and Story Maker), but only Certificate Maker was among the favorites students wanted to use and even that package contained figural components. In all likelihood, this is not a reflection on the quality of these packages, but instead is an indication of the students' desire to work with materials outside the regular curriculum. Students appeared to welcome the opportunity to work in a highly spatial environment. The experimenter observed that students requested figural packages more often, worked longer with these packages, and would seek approval from their peers more often when working with figural software.

No differences existed between the groups on Schaefer's Creative Attitude Survey. That is, there was no evidence the divergent computer software experience affected creative attitudes when compared to those receiving the convergent treatment. One explanation might be that the convergent group spent 25 hours in an environment that allows for student self-selection, an exploration of ideas, a private and nonjudgmental environment, continuous interaction, immediate feedback, and a number of alternative solution paths that eventually lead to the one convergent answer. Thus, the route the convergent group followed to the one right answer might have increased their creative attitudes. However, since they were not involved in constructing anything new or original, this treatment did not increase their figural creativity. Nevertheless, the number and types of tests within this study precluded the use of an additional control group without any software treatment.

Critical thinking was not significantly affected by the convergent treatment. There are several possible reasons for the lack of the expected treatment effects for this group. First, the reading level of the Cornell tests might have been too difficult for these children. Almost half of the subjects were 4th-graders, the lowest applicable age group for this test. Secondly, none of the convergent packages directly addressed the credibility of sources or the assumption identification subtests. Finally, it is possible that the Cornell Critical Thinking Test was an inappropriate measure of the effectiveness of these packages. Many of the convergent programs were designed to facilitate visual discrimination and figural reasoning skills (e.g., Gnee or Not Gnee, Moptown Hotel, Logic Builders, Odd One Out, The Pond, Teddy's Playground, and Think Quick). A more appropriate test might have been the Ross Test of Higher Cognitive Processes developed specifically for grades 4-6.

The Ross Test has been used to assess the effectiveness of programs that emphasize higher cognitive processes. The packages mentioned in the preceding paragraph directly address the visual discrimination skill components of Section VIII--Analysis of Attributes, while The King's Rule, Puzzle Tanks, and Safari Search are packages used in the present study that deal with the skills evaluated in Section VII--Analysis of Relevant and Irrelevant Information.

This study extends the previously limited work into the creative and critical thinking applications of computer software. Even though there were software, testing instrument, and time limitations, there was still an indication from the one significant difference among these groups that segregating software into convergent and divergent uses may have beneficial effects for children in grades 4-6. Additional research is needed to find out whether the effects would be more significant if students were exposed over longer time periods, especially as more convergent and divergent software becomes available.

Given the results of this study, it is recommended that research be attempted with larger and more homogeneous populations. Children in grades 4-6 may differ too much from one another for there to be statistically significant findings. That is, the within group variance of the present study may have been so great that it eliminated any between group possibilities for significant differences.

Other assessment instruments and software programs should be tried in order to determine whether the results of this study can be strengthened. Future research could address questions from a developmental standpoint. There may be critical time periods when this type of software would be most beneficial. Still other studies might investigate more specific components of thinking (e.g., spatial reasoning, pattern recognition, and figural analogies), with software aimed at nurturing that skill.

Thus, there are a number of directions research into thinking skills and the computer could take. Studies like the present one redirect attention from computer literacy and computer programming to a new culture, where the computer is a tool to be used for the building of inquiry and other generalizable problem solving skills. Further research in this area could catapult researchers and teachers from the speculation stage to the development of specific programs that could be implemented within the curriculum. We should now begin to consider and experiment where this could be done most effectively.

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Table 1

Listing of Packages Used In the Study by Group

Divergent Packages (Group One)	Convergent Packages (Group Two)
Animate	Blockers and Finders
Certificate Maker	Code Quest
Create With Garfield	Drawing Conclusions
Creative Thinking & Problem Solving	Gnee or Not Gnee
Creativity Unlimited	High Wire Logic
Dazzle Draw	The King's Rule
Drawing Board	Logic Builders
Facemaker	Moptown Hotel
The Factory	Odd One Out
Fantavision	The Pond
Kid Writer	Puzzle Tanks
The Incredible Laboratory	Reading Between the Lines
Mask Parade	Recycling Logic
Newsroom	Rocky's Boots
Pattern Maker	Safari Search
PictureWriter	Snooper Troops
The Print Shop	Tales Of Discovery
The Professional Sign Maker	Tales of Mystery
Rainbow Painter	Teddy's Playground
Ruby The Scene Machine	Think Quick
Songwriter	Treasure Island
Story Maker	Where in the U.S.A. (and World) is Carmen Sandiego?

Table 2

Means, Standard Deviations, Differences in Means, and t Scores by Group

Measure	Div. Group (n = 20) M	SD	Conv. Group (n = 20) M	SD	Diff.*** In Means	*t* Score
Schaefer	21.30	4.39	21.85	4.79	-.55	-.38
Torrance Verbal:						
Fluency	34.80	15.69	33.95	15.76	.85	.17
Flexibility	18.70	7.71	17.95	7.20	.75	.32
Originality	28.65	16.97	28.10	16.75	.55	.10
Total Verbal	82.15	39.34	80.00	37.86	2.15	.18
Torrance Figural:						
Fluency	27.10	6.83	23.05	4.94	4.05	2.15*
Flexibility	20.80	3.22	19.15	4.15	1.65	1.41
Originality	35.85	10.62	33.15	8.93	2.70	.87
Elaboration	61.15	18.47	57.95	23.42	3.20	.48
Total Figural	144.90	25.59	133.30	32.28	11.60	1.26
Torrance Totals:						
Fluency	61.90	18.10	57.00	17.16	4.90	.88
Flexibility	39.50	8.70	37.10	8.63	2.40	.88
Originality	64.50	21.98	61.25	21.06	3.25	.48
Elaboration	61.15	18.47	57.95	23.42	3.20	.48
Torrance Totals	227.05	55.99	213.30	60.83	13.75	.74
Cornell:						
Induction	13.05	3.59	13.40	3.79	.35	.30
Credibility	11.30	3.01	10.45	3.59	-.85	-.81
Deduction	6.05	3.02	7.05	3.76	1.00	.93
Assumption Ident.	4.35	2.11	3.05	1.57	-1.30	-2.21**
Cornell Totals	34.75	8.16	33.95	9.69	-.80	-.28

* The asterisk denotes that this is a significant difference. With the alpha-level = .05, the critical value t_{38} (.95) = 1.69.

** The *t* score for assumption identification is not a significant difference, since the original directional hypothesis specified that the convergent group would score higher than the divergent group on every measure of the Cornell Critical Thinking Test.

*** Differences in means on the Torrance and Schaefer tests were calculated by subtracting the convergent group mean from the divergent group mean. The reverse approach was used for the Cornell scores where the divergent software group becomes the control.