Effects of Technology on Critical Thinking and Essay Writing Among Gifted Adolescents

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This article presents results of a study that compared critical thinking in two writing samples (essays) from gifted adolescents who attended a residential school. The essays were written at the beginning of the junior year (when students were admitted to the school) and at the beginning of the senior year. All students in the study composed their first essay in handwritten form. On the second essay, some students were randomly assigned to a computer condition and composed their essays on the computer. Results demonstrated a gender-specific effect of using computers to compose essays. Boys using the computers produced significantly more words, sentences, and paragraphs than boys who did not use the computer to write and received higher ratings on a structured rubric. Girls scored the same in both conditions and performed consistently at a level on par with the boys using computers.

In this time of technology assisted learning, students are not only familiar with how to use a computer, but they are also quite knowledgeable about the variety of tasks that can be enhanced through computer applications. Technology-fluent students carry their laptops to class to facilitate note taking and to add reflections during class in the most efficient manner they can manage. In addition, they use the Internet to solve problems, as well as to find necessary research information for support in papers and projects. Schools that provide access to computers often incorporate trips to computer labs or have computers available in the classroom as part of the writing process so that students can write their essays in school as regularly scheduled parts of classes. Those promoting computer use assume that computer use is natural and does not impede the thinking process; rather, it is seen as a fluid way to express thinking in a format that is easier to read and edit and gives more time for critical thinking (Hartley, 1993). It is important to consider whether ready access to computers actually enhances critical thinking or whether it merely provides students with a tool that helps them finish tasks quickly in a more acceptable, finished form without additional editing and revision. Whether this efficiency attenuates students' critical thought processes that lead to revisions that ultimately promote quality in writing is a major consideration of this research project.

Critical Thinking and Writing

In considering the interface of critical thinking and writing, it is essential to examine first the importance of each of these constructs and then the way they impact the education of high-ability adolescents. Scholars cite Socrates as the initiator of the art of critical thinking because of the importance he attributed to ideas and their role in directing the conduct of everyday life. Certainly, the Socratic dialogues are excellent examples of critical thinking in action (Campossela, 1996). John Dewey, however, coined the term *critical thinking* in the 1930s, but preferred to call it *reflective thinking*, defining it as "active, persistent, and careful consideration of any belief or supposed form

of knowledge in the light of the grounds that support it and the further conclusions to which it tends" (Dewey, 1933, p. 9). Unlike many of the other developers of theories of critical thinking, Dewey did not suggest a series of steps to use in the process of reflective thinking. Rather, he suggested that reflective thinking was a disposition that included living with uncertainty; that is, risk-taking. He stated, "One can think reflectively only when one is willing to endure suspense and to undergo the trouble of uncertainty" (p. 116). Dewey saw reflective thinking as a series of connections, of relationships, and he believed that "only when relationships are held in view does learning become more than a miscellaneous scrap bag" (p. 77).

Continuing with the idea of reflection as a dimension of critical thinking, Ennis (1989) defined critical thinking as reasonable and reflective thinking that is focused on deciding what to believe and do. Later, Paul (1996) argued,

> To become a critical thinker is to practice skills that enable one to start to take charge of the ideas that run one's life. It is to think consciously and deliberately and skillfully in ways that transform oneself. It is to run for the first time one's inner workings and to understand the "system" one is running. It is to develop a mind that is analogous to the body of a person that is physically fit. It is like an excellent dancer who can perform any dance that can be choreographed. It is like a puppet that discovers the strings and figures out how to gain control of the way they are pulling. (p. 76)

Indeed, both Ennis and Paul and Elder (2001) have emphasized that a major facet of critical thinking involves examining assumptions that underlie thought and action. Because assumptions provide the intellectual background for the rational pursuit of knowledge, examining them carefully and evaluating them thoughtfully are worthy pursuits in educational settings. In considering the process of critical thinking, Yanchar and Slife (2003) have suggested that it has two parts: the first requires knowledge of the assumptions and underlying worldviews of a particular discipline or field of inquiry; the second involves developing ideas and assumptions that are alternatives to present views.

Hence, the act of critical or reflective thinking seems to require time for it to transpire. In addition, focus is important. Halpern (1984) defined critical thinking as directed thinking; that is, critical thinking has a purpose or a goal toward which it is directed. Halpern differentiated critical thinking from other types of thinking that are routine and do not focus on a purpose. Problem solving, making an inference, or making a decision require critical thinking. Additionally, Halpern has suggested that with hard work, practice, and determination, most people can improve the way they think—but they must approach each task with critical thinking.

Writing is a vehicle through which students can readily express their critical thinking. McKeachie, Chism, Menges, Svinicki, and Weinstein (1994) argue that learning to think critically requires contemplation and communicating the thinking through talking, writing, or doing so that others can react to it. Indeed, writing seems to be an expression of critical thinking when students are trained to use a critical thinking method consistently in writing. Dixon (1996) found that evidence of critical thinking in writing increased after students were trained to use a strategy based on the Hegelian Dialectic. The Dialectic asks students to determine a thesis, counter with an antithesis, and consider both sides in determining a synthesis. Students in the experimental group used the process of the Hegelian Dialectic daily in discussion and writing during a 6-week period. Dixon found the experimental group scored significantly higher on an analytical thinking measure adapted from the criteria used to score essays for the AP English Composition Examination. She concluded that writing was an excellent way to express critical thinking. In addition, the Hegelian Dialectic is a strategy that focuses on a thesis, a statement of a major idea that directs examination. The fact that writing flows from a central thesis makes the Hegelian process a good fit as an outcome for this strategy.

Similarly, Dlugos (2003) has suggested modifying course content to explore how conventional student assignments can be expanded to include critical thinking and writing about one's experiences, attitudes, and values relative to the main concepts of the course. A central assumption of most instructors is that critical thinking about one's experiences, attitudes, and values goes hand-in-hand with personal growth and development, and, therefore, writing about these experiences is a chance to critically think about them. This writing about one's own experiences seems more subjective than objective, more reflective than critical. However, the process of transforming even personal thoughts into sources for critical thinking and thus writing about them adds a dimension of commitment to ideas that can be exposed to critical evaluation.

Computer Assisted Writing

The addition of computers to the composition classroom has long been heralded as a means of improving the

writing process by removing the barriers in revision that previously existed when paper and pencil were the only available tools used to compose.

Those who write frequently see benefits in adding computers to the process, including enhanced organization, sharpened technical aspects of the composition (e.g., spelling and grammar checking), simplified revision and document merging, easier reading of early drafts of the revision process, and superior efficiency in creating the product (Hartley, 1993). However, research on the addition of computers to the writing process has been far from comprehensive, and the work that has been conducted does not often lead to an easily identified pattern of results. For example, in one recent analysis, this disjointed pattern connected to computer use in writing led researchers to conclude that the effects were essentially random, indicating that the use of computers had no meaningful influence on performance (Dybdahl, Shaw, & Blahous, 1997). On the other hand, our own interpretation of the body of research in question is that the quality and quantity of writing produced by students using computers (as compared to handwritten products) are often driven by methodological variances that are inherent in educational research as generated by several different groups of researchers. Sensitive to these methodological variances, there are meaningful patterns that are instructive and can provide guidance to the use of computers in students' writing.

Writing quality is one aspect of the writing process that has been studied in relation to the use of computers. In a counterbalanced repeated measures design examining within-subject differences in writing process and product, eighth-grade students received higher ratings on the quality of their writing when using computers to compose their essays (Owston, Murphy, & Wideman, 1992). Observation of students revealed that in the word processing condition, students were more likely to (a) continually check spelling; (b) be in a constant state of revision and rewriting; (c) make use of "cut and paste" features, presumably to improve the flow and organization of the paper; and (d) make more fine-grained, or microstructural changes during the draft creation phases of writing. Interestingly, in this study no differences were found in the mean number of words produced (Owston et al.). However, the variance in number of words was significantly higher in the word processing condition, suggesting that the word counts were influenced by a skill such as typing that may interfere with overall efficiency in text creation.

A later study conducted by Owston and Wideman (1997) added significantly to the field's understanding of the potential of computers in writing. Rather than examining the effects of computers on a single assignment or in one condition versus another, they explored the overall growth of students' writing abilities from third to fifth grades in high- and low-computer access schools. The results provided a dramatic demonstration of computers becoming ubiquitous to the students' learning environment and also revealed significant and meaningful differences in the quality of written text, as well as the length of those texts. The students in the high-access school also demonstrated that computers can produce a true additive effect in writing. Specifically, when tracking the number of texts constructed by students by the third year of the project (as fifth graders), the high-access school participants created as many handwritten texts as their counterparts. In addition, the high-access students doubled this level of writing productivity by creating even more texts on the computer (averages: 4.4 handwritten texts; 5.1 on computer-written texts) while the students in the low-access school generated almost no texts on the computer (averages: 4.1 handwritten; 0.1 computer-written).

The use of computers in the classroom has also influenced writing fluency, another dimension of the writing process. Investigations of students' writing products often include an analysis of the number of words and sentences produced in the experimental and control conditions. The connection between quantity of written material and quality of writing is naturally not a 1:1 correspondence. However, if individuals are shown to be able to generate consistently more text in an allotted time span when using the computer than when writing by hand, then the conclusion is that their composition process is more "fluid" and presumably natural in the word processing condition. The research appears to support the proposition that computers do allow for greater "writing fluency," provided that the level of computer experience and student motivation are controlled (see Reed, 1996, for review).

Peterson's (1993) analysis of the fluency provided two notable effects supporting the benefits of computers in writing for high school seniors. First, in initial 30-minute writing session drafts, students using computers composed more content than when they were given 30 minutes to write by hand. Second, when provided with the initial draft at the next class session (Friday to Monday), the computer condition led to a greater number of words that added to the composition. Similar patterns of superior writing fluency have been reported for students in the fifth (Dybdahl et al., 1997) and sixth grades (Nichols, 1996). In these studies, the number of words and/or sentences were the primary differences noted in the repeated measures designs. That is, differences between computer and handwritten products were not found in types of revisions

(Peterson, 1993), ratings of technical quality (Nichols), or holistic judgments of text quality (Dybdahl et al.).

Owston and Wideman's (1997) longitudinal analysis also demonstrated consistent access to computers over time had a meaningful impact on the level of writing fluency. As mentioned previously, the total number of texts created increased. However, in addition to the number of compositions created, a significant increase in the overall number of words in each composition was revealed. In their analyses, Owston and Wideman reported that the low-computer access students generated more and longer final texts than the high-access school during the first year of the project (third grade). However, over the next 2 years, data tracking the mean number of words and number of texts generated revealed that the high-access school students passed their counterparts and held a significant advantage in writing fluency in the fourth- and fifth-grade years. The pattern of results again suggests that there were skills underlying the early advantage seen in the handwriting group (either typing or computer use).

Research on writing with computers has been conducted on special needs populations, demonstrating a positive impact on the writing development of children with learning disabilities (e.g., MacArthur, 1996). However, no clear body of research has explored the effects of using computers in the writing process for high-ability adolescent learners. In addition, the literature on the use of computers to assist high-ability adolescents in composing essays that feature their critical thinking is not plentiful. An important consideration is whether gender has any impact on high-ability performance. Considering the interests of gifted boys, Kerr and Cohn (2001) cite the classic Terman (1925) studies stating,

> With regard to play interests and career goals, Terman found that gifted boys were more like average boys than like average girls. Their interests in both play and careers scored high on his masculinity indices, although he noted that gifted boys liked dramatics, debating, literature, and modeling more than average boys. (p. 53)

Similarly, Coleman and Cross (2001) write, "The interests of gifted boys are more similar to those of nongifted boys than the interests of gifted girls are to those of nongifted girls" (p. 37). In fact, gifted girls' interests are more like gifted boys' interests than they are similar to nongifted girls' interests. In terms of ability, Coleman and Cross stated that girls tend to do better in English, while boys achieve significantly better in science and math. However, when grades are used as the sole criterion, girls receive higher average marks in everything, including math and science.

The goal of our project was to explore the impact of word processing technologies on writing in response to guided prompts. The investigation was restricted to writing samples that were produced in one attempt (no revision stages enabled), much as would be seen in standard essays. Specifically, we sought to answer two questions: First, is the rubric used to evaluate critical thinking scores both valid and useful in measuring the construct? Second, what differences are noted in student writing samples based on the gender of the writer and the mode of creating the written work (technology-supported vs. handwritten)?

Method

Participants

Participants included 99 students (39 males and 60 females) who attend a legislative-supported residential academy for science, mathematics, and humanities. The mean age of the participants at entry to the Academy was 16 years. Located on a university campus in the Midwest, this residential Academy was established in 1990 to serve the educational needs of high school juniors and seniors who desire a more rigorous and focused curriculum than what is offered in regular public schools. Prior to their junior year in high school, students wishing to gain entrance to the Academy must submit an application, standardized achievement or ability test scores, teacher or counselor recommendations, transcripts, and essays to indicate their desire for admittance to the school. Students must also agree to an onsite interview with one or more representatives of the school. Students who are admitted complete their junior and senior years in the residential community. This school does not calculate class rank or grade point averages (GPA). Many educators across the state refer to this school as "the gifted school."

Measures

Critical Thinking. Critical thinking was assessed using the Watson-Glaser Critical Thinking Appraisal (Watson & Glaser, 1980). The Watson-Glaser Critical Thinking Appraisal is a multiple-choice test of reasoning skills that is widely used in studies at the high school and college level. The Critical Thinking Appraisal tests skills of arguments, specifically drawing inferences, recognizing assumptions, evaluating conclusions, and assessing the strength of reasons offered in support of a claim (Kurfiss, 1997). Students

took alternate forms of this test two times: in the fall of their junior year (2001), and again at the end of their junior year (spring, 2002). Form A of the Watson-Glaser is composed of 80 test items following 16 scenarios. All of the items are objective questions in which the test taker selects the answer. There are five content areas: Inference, Recognition of Assumptions, Deduction, Interpretation, and Evaluation of Arguments. A student receives a single score based on the completion of the test. The internal consistency reliability (coefficient alpha) for the measure was .85; test-retest at a 3-month interval was reported at .73; alternate forms reliability was reported at .75. In our analyses, we have also examined the raw scores for each of the five content areas to provide more fine-grained examination of critical thinking skills.

Essays. Critical thinking was also measured in essays gathered from the participants at two different administrations. The first essay prompt was administered to all juniors as an entry essay at the beginning of their junior year. The second essay prompt was administered during the fall semester of their senior year (2002). All students in the study composed their first essay in handwritten form. On the second essay, some students were randomly assigned to a computer condition and composed their essays on the computer. Both prompts were based on an essay by Katherine Anne Porter. English teachers at the school selected the initial reading. The students were instructed to read the passage carefully, taking notes if they desired. They were told that it was acceptable to make changes to their text as they worked and that their writing would be assessed based on the following characteristics:

- a response that addressed the topic and the assignment,
- a thesis statement,
- specific development of the thesis, using details from the passage as evidence,
- analysis (discussion) of the evidence,
- logical organization,
- coherence of thought,
- clarity of expression, and
- observance of the rules of grammar and mechanics.

The second prompt included the writing guidelines, referred to and included the initial Porter essay, and extended it. The second prompt is included in the Appendix.

Essays were scored for critical thinking using a rubric adapted from the AP English Composition rubric (Dixon, 1996). The major focus of this rubric (see Table 1) was on critical thinking (analysis, synthesis, and evaluation of ideas) expressed in the essay rather than the writing mechanics.

Table 1

Rubric for Scoring Essays

5   Organized and well written essay that clearly analyzes the literature with specific references and cogent explanations. These essays are free of plot summary that is not appropriate to analysis.

4   These essays analyze the topic well but are less incisive, developed, and supported than the highest category. They deal accurately with language and demonstrate the writer's ability to express ideas clearly.

3   These essays are superficial. Writers chose a topic but the explanation is vague or over-simplified. They reveal simplistic thinking; they demonstrate inconsistent control over the elements of composition and do not convey higher level thinking.

2   These essays are unpersuasive, perfunctory, underdeveloped, and reflect misguided analysis. They contain little, if any, supporting evidence. They summarize plot at the expense of analysis.

1   These essays seriously misread the work of literature they explore. They are unacceptably brief. The views have little clarity or coherence. Essays that are especially inexact, vacuous, ill-organized, illogically argued, and/or are mechanically unsound should receive 1.

In addition to the rubric ratings of quality in writing, we examined basic features of the writing samples provided by the students. These simple features included number of words, sentences, and paragraphs offered in each writing sample.

Raters

Two raters were trained to score both administrations of the essays. Raters were two English instructors at the school who were interested in working on the project and were experts in writing and in assessing writing. Training occurred on four occasions. At the first session, the rubric was explained and examples of each level of the rubric were presented to the raters. They read the essays and asked questions to clarify their notions of what each level represented. Then they practiced coding essays. Each rater coded 10 essays and scores were compared. They practiced on three different occasions after the initial explanatory session. The goal was to establish interrater reliability at .70 on the practice essays before beginning to rate the

sample essays. Subsequent training sessions involved practicing coding essays, checking scores for congruence, and discussing the reasons for lack of agreement. When training was completed, and interrater reliability was established at .70, the raters independently scored the essays for each administration, naïve to the identity of the students creating the essay. For any essay where the two primary raters did not reach initial agreement, the rubric creator and trainer for the two raters coded the essays. In this way, all essays were assessed with the same rating by two raters. Initial interrater reliability estimates for the two primary raters for the data in this study was .60. To overcome the reduced consistency found in initial rating, the rubric creator and trainer coded all essays that did not receive matching scores. In all cases, this expert rating matched one of the initial codes; therefore, all reported values are based on converging values from two independent raters.

Results

The results examined two primary issues. First, we evaluated the utility of the writing rubric by comparing critical thinking scores and basic writing indicators. Second, we explored the scores generated through this rating scheme and investigated differences based on gender, as well as the impact of using computers to write the posttest essays.

Essay Analyses

A fundamental assumption underlying the scoring rubric for essays was that the holistic value would provide an indicator of high quality writing that demonstrated critical thinking skills. In addition, the scoring rubric was developed such that the length of the passage was not necessarily linked to the eventual score. To test these two assumptions, we conducted correlational analyses investigating the relationships among writing scores, performance on the Watson-Glaser Critical Thinking Appraisal, and basic measures of students' writing output (number of words, sentences, and paragraphs). The intercorrelation matrix displayed in Table 2 displays that the writing sample score was correlated with number of words and the subset of Watson-Glaser items determining "inference." The Watson-Glaser Critical Thinking Total Score approached a level of statistical significance ($p <$ .03), but given the number of variables in the analyses, a meaningful relationship could not be confidently determined. We repeated the analyses with the second writing sample to identify the stability of the relationships

revealed in this correlational model. In the second essay, the score on the essay rubric was significantly related to (a) score on the first essay, $r = .32$; (b) Watson-Glaser Total Score, $r = .29$; and (c) number of words produced, $r = .34$ (all p's < .005). The correlation between rubric rating scores and deduction and interpretation approached significance in this sample. However, caution generalizing these results is warranted as the full sample was used in these analyses, neglecting the form of production in the writing task (handwritten vs. word processing).

These results combine to suggest that the method for scoring the writing sample is not a direct measure of critical thinking, but is related to components of critical thinking, in particular inference. The significant relationship revealed with number of written words is not a feature of the rubric, but is also not surprising. It is possible that students completing the writing samples with "more to say" would be able to perform more satisfactorily on the total writing rubric scoring system.

Factors Influencing Writing Performance

The main question of the study was the impact of word processing on students' writing performance, while maintaining focus on potential gender effects. To analyze the effects of gender and word processing, a 2 (male, female) by 2 (word process, handwrite) repeated measures multivariate analysis of variance was employed, examining four dependent variables at two points in time (WS-1, WS-2): writing sample quality rating, number of words, number of sentences, and number of paragraphs. Given the unequal sample sizes, threats to homogeneity of covariance, and small sample size in this study, Pillai's Trace was used to interpret the MANOVA (see Table 3). The results of the MANOVA revealed statistically significant main effects for gender, method of writing at WS-2, and the repeated factor (time). In addition, the interaction effect between method of writing at WS-2 and time was statistically significant.

To provide meaningful interpretation of these significant effects, a set of descriptive discriminant analyses were performed to address what aspects of the writing performances were influenced in this study. First, to explore the effect of gender on initial writing performances, we contrasted girls' and boys' performances on WS-1. Recall that all participants were required to handwrite their responses for this essay. As such, Table 4 presents the gender comparison for this writing sample without disaggregation based on the method of writing for WS-2, which was not a relevant factor for this initial writing condition.

Table 2

Intercorrelation Matrix for Writing Variables

	1	2	3	4	5	6	7	8	9	10
1. Writing Score										
2. Numb. Words	.37*									
3. Numb. Sentences	.18	.40*								
4. Numb. Paragraphs	.19	.79*	.42*							
5. WG: Inference	.31*	-.05	-.03	-.07						
6. WG: Recognition.	.02	-.08	-.09	-.10	.19					
7. WG: Deduction	.14	-.11	-.09	-.01	.47*	.23				
8. WG: Interpretation	.17	-.05	-.07	-.07	.44*	.22	.47*			
9. WG: Evaluation	.10	.03	-.01	-.06	.37*	.15	.38*	.27		
10. WG: Total[a]	.21	-.08	-.09	-.09	.73*	.61*	.73*	.68*	.62*	

[a] Watson-Glaser Total Score is a combined score derived from all other WG subscores.
*$p < .005$.

For the WS-1 comparison, the single discriminant function represented a reliable relationship between the predictors and gender, $\chi^2 (4) = 12.636, p < .01$. Examination of the structure matrix revealed gender differentiation was a product of writing production, not writing quality scores. The structure coefficients for the four measures taken during WS-1 revealed that number of sentences was the strongest predictor of gender differentiation (structure coefficient = .99), with number of words (.78) and number of paragraphs (.67) exceeding the .63 criterion established by Comrey and Lee (1992) to indicate "very good" coefficient loading. The writing quality score coefficient (.24) revealed no reliable differences between girls and boys in ratings on the scoring rubric during the initial writing sample.

To examine the effects of gender and use of word processors on the students' writing performances across the two conditions, a second discriminant analysis was conducted. To simultaneously examine the effects of gender, method of writing at WS-2, and the repeated factor, the discriminant function analysis was designed to predict membership in one of four contrived groups: males/word processing, males/handwriting, females/word processing, and females/handwriting. To capture the effect of the repeated factor, the predictor variables were the participants' change scores on the four ratings derived from the writing samples (rubric rating, number words, number

Table 3

Repeated Measures Analysis of Variance Summary Table

	Pillai's Trace	F (4, 90)	p
Between Subjects			
A. WS-2 Writing Method	.20	5.57	.001
B. Gender	.12	3.07	.02
A X B	.09	2.38	.06
Within Subjects			
C. Time (repeated)	.55	26.93	.001
A X C	.15	3.97	.005
B X C	.04	.87	.48
A X B X C	.02	.49	.74

sentences, number paragraphs; see Table 5). With four contrived groups, there were three computed discriminant functions. Only the first function was a reliable predictor, accounting for 79% of the between-groups variance, $\chi^2 (12) = 22.45, p < .03$. The second function accounted for 20% of the variance, $\chi^2 (6) = 4.95, p > .50$, while the third

Table 4

Gender and Writing Condition Performance Averages

	WS-1 (Handwritten)[a]		WS-2 Handwritten		WS-2 Word Process	
	Female $n = 60$	Male $n = 39$	Female $n = 31$	Male $n = 22$	Female $n = 28$	Male $n = 16$
Writing Performance Rating	3.40 (.72)	3.26 (.97)	4.10 (.87)	3.18 (1.22)	4.00 (.94)	4.13 (1.08)
Number of Words	286.02 (106.46)	229.00 (88.40)	395.45 (133.37)	264.91 (90.83)	478.61 (149.46)	461.56 (116.90)
Number of Sentences	19.15 (7.94)	14.41 (5.22)	23.90 (11.63)	16.23 (6.03)	28.00 (12.50)	26.62 (8.59)
Number of Paragraphs	4.37 (1.76)	3.64 (1.44)	4.13 (2.40)	3.23 (2.00)	5.04 (2.10)	4.88 (2.06)

[a] All participants completed WS-1 as a handwritten exercise, so only gender differences are displayed in this table.

function accounted for only 0.5% of the variance, χ^2 (2) = .13, $p > .50$. As such, only the first function is interpreted, which revealed that the differentiation among the groups was determined by writing productivity. Specifically, the discriminant function differentiated between those using word processors and those handwriting the second essay with two clearly meaningful variables: change in the number of words produced (structure coefficient = .93) and change in the number of sentences produced (structure coefficient = .65). Change in scores on the writing rating rubric (structure coefficient = .31) met the base minimum criterion for coefficient strength (Tabachnick & Fidell, 2001), while change in number of paragraphs was not a reliable predictor. No gender differences were revealed in the comparison of the change scores.

Therefore, the data analyses demonstrated that girls produced more handwritten content in the initial writing sample, when all students were required to handwrite their responses. The change scores demonstrated a significant effect of the use of computers on writing production (words and sentences) regardless of gender, and a small effect was evident for writing sample rubric ratings. Examination of the means presented in Tables 4 and 5 reveals a trend in which use of the computer (available only in WS-2) helped adolescent boys generate more text in response to the writing prompts, bringing the amount of written work in line with their female counterparts. Reviewing the means in Table 4 also illustrates the dramatic difference on the essay rubric scores when comparing the boys in the handwritten and word processing conditions. Given the primary interest in this study on the effect of computer applications on writing quality, an independent samples t-test of boys' writing sample rubric ratings for WS-2 was conducted to compare the handwriting and word

Table 5

Change Score Averages for Gender and Writing Condition Groups

	WS-2 Handwritten		WS-2 Word Process	
	Female $n = 31$	Male $n = 22$	Female $n = 28$	Male $n = 16$
Writing Performance Rating	.71 (.69)	.14 (1.25)	.61 (1.13)	.56 (1.36)
Number of Words	105.71 (164.09)	54.91 (99.58)	201.54 (148.12)	203.25 (167.79)
Number of Sentences	4.12 (11.61)	2.77 (6.26)	9.61 (11.84)	10.94 (8.64)
Number of Paragraphs	-.16 (2.53)	0.00 (2.20)	.61 (2.42)	.69 (1.89)

Note: Change score calculation: WS-2 – WS-1

processing conditions. The difference was statistically significant and in favor of the word processing group, t (36) = 2.50, $p < .01$.

Discussion

Our study examined the impact of technology on writing in an adolescent gifted population. In addition, although critical thinking is a term widely used in gifted education literature, few studies that measure critical thinking are available. So, this research is a contribution to the field of gifted education. The results yielded some

interesting considerations. First, the Dixon (1996) rubric used for coding and scoring essays was useful in reveling limited aspects of critical thinking. This makes sense because deduction requires one to establish or identify a general idea and then support it with examples (Ennis, 1989) and inference requires making connections in ideas. Well-thought-out essays do this exact process: that is, they focus on a thesis, which is then supported by examples to elucidate the thesis.

Second, when gifted boys used word processors to respond to a writing prompt, they composed better essays than when they were required to handwrite them. Our study indicated that on Essay 1, when the students were required to handwrite their work, the boys produced an average of 229 words. On the other hand, on Essay 2, those with access to computers produced an average of 420 words on their essays compared to 265 words from boys who composed handwritten essays on Essay 2. This 83% increase in word production in the word processing condition may be attributed to the ease and speed in writing that they were able to achieve in the same amount of time. That is, it is quite likely that the computer-experienced students in this population simply type faster than they write, and were inclined to stop writing after a period of time rather than bringing their open-ended essays to a conclusion. In this way, the benefit of computers to gifted adolescent students (particularly males) appears to be a simple matter of speed and efficiency.

Kerr and Cohn (2001) state,

> When intellectual development outpaces motor skills, the gifted boy may be continually frustrated by his inability to make his hands and body do what his brain insists he do. He cannot write as fast as he can think. . . . How wonderful the advances of technology have been for gifted boys . . . a software program can give him the dexterity he needs to bring his images to reality—at least on the computer screen. (p. 115)

Indeed, computer technology seems to help bridge the writing gap for gifted boys. In addition to an increase in words, the boys in the computer group also increased the number of sentences and paragraphs in their writing, as well. Their scores on the Dixon rubric (measuring critical thinking) on Essay 2 averaged 4.1 compared to an average of 3.1 for those boys in the handwritten group. The males seriously outperformed their earlier attempt at writing using critical thinking with their use of computers. This suggests that computers may have a remediating effect on males.

Female participants in this study, on the other hand, performed more consistently on both essays (average rating of 4.1 on essay 1 and 4.0 on essay 2). Their performance did not seem to change regardless of what format they used. They were overall more reflective and generated more words, sentences, and paragraphs. Because gifted girls in high school report higher levels of interest (motivation) and confidence in their skills for English (language arts) than boys (Li & Adamson, 1995), our results are consistent with other research. Indeed, overall, on all measures—critical thinking, number of words, sentences, and paragraphs generated—females scored higher than males in the handwritten condition. However, the most significant finding was the improvement that the males made when they were able to compose essays on computers.

A distinct limitation of this study is the number of participants. Other limitations include our lack of data on computer expertise, and the interest of the students in writing, computers, or other specific topics. In addition, the rubric used was not a strong measure of critical thinking in general in this study. However, the results certainly emphasize the importance of format when requiring students, particularly boys, to write.

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Appendix
Prompt for Essay II

Katherine Anne Porter writes about attending a bullfight in the attached excerpt of her essay. Earlier in the essay (in an omitted section) she explains that a friend, a man named Shelley, took her to her first bullfight. She mentions being a visitor as she states, "And I did not really live in that world, so narrow and so trivial, so cruel and so unconscious; I was a mere visitor." Write an essay, in first person, that discusses your experience of being a visitor to a world that you do not fully understand at first and then become "totally absorbed in" later. Refer to Porter's description as you describe your description as clearly as you can.