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ABSTRACT

Uses of the computer to support the development of writing skills was examined in a computer-intensive educational context, the Apple Classroom of Tomorrow (ACOT). Subjects were 55 sixth-grade minority students, 25 of whom were ACOT participants and the remainder members of a matched control group attending the same school. Computer-based writing experiences consisted of using word-processing as a primary classroom writing mode and electronic mail as a supplementary activity. Results from a year-long study indicated high enthusiasm and preference by ACOT students for word-processing applications, which they used naturally and routinely for virtually all writing tasks. The electronic mail component was regarded as less effective due to hardware problems and the lack of an organized activity plan. Evidence for the achievement benefits of the computer-based writing program was provided by the superiority of the ACOT group over the control group on writing samples collected during the school year. (2 tables, 32 references) (Author/BBM)

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The Development of Writing Skills in a Computer-Intensive Environment

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Abstract

Uses of the computer to support the development of writing skills was examined in a computer-intensive educational context, the Apple Classroom of Tomorrow (ACOT). Subjects were 55 sixth-grade minority students, 25 of whom were ACOT participants and the remainder members of a matched control group attending the same school. Computer-based writing experiences consisted of using word-processing as a primary classroom writing mode and electronic mail as a supplementary activity. Results from a year-long study indicated high enthusiasm and preference by ACOT students for word-processing applications, which they used naturally and routinely for virtually all writing tasks. The electronic mail component was regarded as less effective due to hardware problems and the lack of an organized activity plan. Evidence for the achievement benefits of the computer-based writing program was provided by the superiority of the ACOT group over the control group on writing samples collected during the school year.

The Development of Writing Skills in a Computer-Intensive Environment

Using computers to teach and develop writing skills a topic of considerable research interest. In the specific case of word-processing, the important advantages are viewed as facilitating the revision and editing of drafts, and improving student attitudes toward the writing process (Collins, Bruce, & Rubin, 1982; Daiute, 1985a; 1985b; Heebner, 1988; Quellmalz, 1989). MacArthur (1988) and others (Daiute, 1985a; Calkins, 1986) have further emphasized the potential impact of the computer on the social context for classroom writing.

Although many authors and researchers agree that use of a word-processor can improve attitudes and confidence about writing (e.g., MacArthur, 1988; Madian, 1986; Newman, 1984; Rodrigues, 1985; Strictland, 1986; Sudol, 1985), there is little evidence from well-designed studies that indicate its impact on writing improvement. Rather than trying to establish the computer's "effect" on writing improvement (see Clark, 1983), it would seem more productive to investigate ways in which computer-based writing activities can be effectively integrated with the curriculum and conventional classroom activities. One type of activity consists of "computer-specific" applications, such as electronic mail or teleconferencing (Heebner, 1988; Ross, Smith, Morrison, & Erickson, 1989), which extend the forms of writing that can be achieved with conventional (paper and pencil) methods. Another entails "computer supported" applications (such as word-processing) in which the normal writing curriculum and teaching methods can be maintained, but the computer is used as a primary classroom writing medium. Unfortunately, insufficient computer resources at most schools severely limit students' access to computers and thus the opportunities to implement substantive writing programs of either type.

In the present research, the establishment of a unique elementary school environment, the Apple Classroom of Tomorrow (ACOT), permitted examination of long-term uses of both computer-specific and computer-supported writing applications. ACOT comprises an experimental computer-saturated environment in which each student receives a personal computer to use during the school day and another one to use at home. We were thus able to examine students' writing activities under conditions that anticipate future educational environments in which computers will be highly accessible as a support tool both in and out of school. In addition to using word-processing as a primary writing mode, students communicated with one another and with college student tutors via written messages transmitted over an electronic Bulletin Board System (BBS).

A distinctive aspect of the present ACOT classroom relative to 15 others nationwide was its location in an inner-city school attended almost exclusively by minority, "at-risk" students. The availability of a matched control group attending the same school permitted a quasi-experimental design to be employed in assessing program influences on writing performance. However, in view of the complexity of the various ACOT interventions (writing related and otherwise), and the associated threats to internal validity, the group comparisons were supplemented by extensive qualitative and quantitative data from interviews, surveys, and observations of ACOT participants involved in the writing component. Major research questions addressed were as follows:

1. How is writing taught and integrated with other learning activities in the computer-saturated, ACOT environment?

2. What are students' attitudes toward practicing writing using word-processing and electronic mail?

3. How do teachers view the strengths and weaknesses of the ACOT experiences for developing writing skills?

4. Do the ACOT writing components appear beneficial for improving writing quality relative to conventional methods?

Method

Subjects

Subjects were 55 sixth-grade minority (Black) students attending the same inner-city elementary school in Memphis, Tennessee. Twenty-five students were members of the sixth-grade ACOT class and 30 were members of a conventional (control) class. Based on their backgrounds, home environments, and academic records, nearly all of these students can be considered academically at risk (see Slavin & Madden, 1989). Analyses of scores on the reading vocabulary, reading comprehension, and language mechanics subscales of the California Achievement Test (CAT), administered in the fall and spring of the fifth-grade school year, failed to establish either the ACOT or the non-ACOT classes as superior (Kitabchi, 1988). Based on these results and informal teacher evaluations, neither group appeared to have an advantage over the other in writing ability at the start of the study. However, because assignment to classes was not completely at random, differential selection (Campbell & Stanley, 1963) cannot be ruled out as an internal validity threat to the group comparisons.

Design

This study was a descriptive and quasi-experimental evaluation of the writing activities and skills achieved in a computer-saturated elementary school class. Outcomes examined included (a) the nature of writing activities in the ACOT classroom; (b) experiences and attitudes of teachers, students, and tutors regarding those writing activities; and (c) differences between ACOT and control students in writing skills. These outcomes were assessed by a variety of quantitative and qualitative measures including interviews, written surveys, classroom observations, and writing samples collected from students during the year. Although the experimental and control groups appeared to be comparable in student abilities and characteristics (see above section), and followed the same basic sixth-grade curriculum, they were taught in different classrooms and by different teachers. Thus, many extraneous factors, aside from type of writing program used (computer-based or conventional), could have contributed to any differences in performance. The writing skills analysis was therefore regarded primarily as a source of suggestive evidence about program effects, not as a basis for supporting causal interpretations.

The ACOT Classroom

ACOT was initiated in 1983 as an experimental partnership between Apple Computer, Inc. and 13 public school classrooms in five states. The rationale was to create "innovative learning environments" that take full advantage of technology, study how these environments affect learning and teaching, and promote positive changes based on the results (Baker & Herman, 1989; Kitabchi,

1987, 1988). The common feature across sites was the availability of computers and software for each student to use in the classroom and at home. Each of the sites, however, was given freedom to develop its own program goals and strategies for achieving them.

For the present ACOT site, the overall project objective was to improve the basic learning skills of its at-risk student population. One of its program activities was the establishment of the electronic mail component to link students with tutors at a local university (Ross, Smith, Morrison, & Erickson, 1989). The tutors assisted students with homework assignments, assigned supplementary work, and provided personal encouragement. The electronic bulletin board system (BBS) used for the mail exchanges was operated locally by an ACOT staff member. A detailed description and evaluation of the BBS component is provided in Ross, Morrison, Smith, & Cleveland (1989).

Additional program emphases were supplementing conventional instruction by encouraging teachers to use telecommunications, multimedia, and curriculum software tools to enrich learning of basic subjects. As will be described below, the most pervasive of these activities was regular classroom and home use of word-processing (using the AppleWorks word-processor) for school writing assignments.

Classroom Writing Activities

What mainly distinguished the ACOT writing activities from those of conventional class was the students' extensive, routine use of word-processing to complete homework and in-class writing assignments. Homework in various subjects was completed on the word-processor at home and printed out at school. Specific writing assignments included journal reports, letters to pen pals, and English compositions. On occasion, exercises oriented around writing skills covered in the textbook were devised for practice on the word processor. Students had composition for one 40-minute period a week and were allotted 20 minutes a day for specific writing assignments. During the day, however, students usually had access to their computers to complete regular classroom assignments in different subjects. The Tennessee Instructional Model (TIM), a direct instructional teaching orientation, was followed for instruction in writing and other subjects.

The electronic mail program was also intended for use in developing language skills and vocabulary through the completion of exercises assigned by the students' tutors. These assignments, however, were sporadic and few in number. Greater emphasis was given to involving students in using the BBS writing to communicate informally with their friends and tutors. For these exchanges, the content of the messages was stressed; no corrections of spelling or grammatical errors were expected or typically provided.

Although the control students had fairly extensive contact with computers as a result of taking a one-hour computer literacy class each day for the entire year, they did not work with computers during regular class time. Rather, they were taught in the traditional manner, using the same language arts curriculum and objectives as the ACOT students, but with pencil-and-paper materials exclusively. As in the ACOT class, the TIM orientation was followed in presenting lessons. In general, ACOT and control classes appeared to be fairly comparable in (a) allocated time for writing, (b) basic teaching methods (e.g., TIM), (c) learning materials other than computer-based resources, and (d) curriculum objectives. Major variations consisted of the assignment of groups to

different classrooms and teachers, and the ACOT group's use of a word-processor for completing most of their written assignments and electronic mail to communicate with peers and tutors.

Instrumentation and Data Collection

Writing assessments. Writing assessments were administered in January and April of the school year to evaluate the writing skills of the ACOT and control classes. Both samples were written by both groups using paper and pencil. In the first (January) writing sample, the students wrote a paragraph describing an apple. The exercise began with the teacher asking students to "brainstorm" about its possible uses, importance, features, and so on. The students were then instructed to write their paragraphs, paying attention to organization, grammar, and spelling. The second writing sample (April) was a letter to the school principal addressing the issue of whether students should have individual computers at their desks.

The paragraphs were evaluated without knowing the writer's identity or treatment group by two English teachers. The criteria were based on skills commonly taught throughout the communication acts curriculum adopted by the state and local education system. The first four entries consisted of: (a) counting the number of words, (b) counting the number of sentences, (c) identifying if there was a topic sentence (yes = 1 or no = 0), and (d) counting the number of details in the paragraph. The topic sentence measure specifically involved assessing whether the sentence in question was supported by information or details in subsequent subordinate sentences in the paragraph. Details, in turn, were defined as points, facts, phrases, or explanations defining or elaborating the topic conveyed. Details were counted in each sentence independent of the presence or absence of a topic sentence or of their relationship to the topic sentence.

The second group of criteria addressed grammar. The specific variables are listed below with a brief explanation of how they were assessed.

1. Number of misspelled words. Each misspelling was counted as one error, regardless of whether the identical error previously occurred. A word correctly spelled but having the wrong tense or meaning was counted as a mechanical error (see "6" below) not as a spelling error.

2. Number of sentence fragments. Each fragment that appeared as part of a complex sentence or as a separate simple sentence was scored as one error.

3. Number of run-on sentences. Each grouping of contiguous sentences strung together as one run-on sentence was scored as one error.

4. Number of capitalization errors. Capitalization errors included errors of commission as well as omission. Handwriting, however, was frequently a problem in identifying whether upper- or lower-case letters were used. When such questions arose, the two raters examined the character in question and reached a mutual decision.

5. Use of pronouns. Use of pronouns was evaluated subjectively and globally as "inappropriate" (score = 0) or "appropriate" (1) for producing a clear and effective paragraph.

6. Mechanical errors. Mechanical error scores involved tabulating errors representing: (a) the misuse or omission of articles, (b) incorrect use of the singular or plural form of a word, (c) subject/verb agreement, (d) tense agreement throughout the paragraph, and (e) incorrect punctuation. In addition, redundancy of words or ideas was evaluated by a dichotomous satisfactory (1) or unsatisfactory (0) rating.

Using a five-point scale ranging from "poor" (1) to "excellent" (5), each paper was evaluated holistically for its unity and coherence in expression. The same evaluation criteria were used with both writing samples, but the letter to the principal (Sample 2) included an additional score indicating whether or not the students used a correct letter form (Yes or No).

The two evaluators discussed each variable to ensure that they had the same understanding of the operational meaning and scoring procedure. After individually scoring several of the same writing samples, the evaluators compared their scores and clarified their definitions of terms and methods. Interrater reliabilities, assessed by correlating the raters' scores on each variable, were quite high, with median *r*'s of .93 and .98 on Samples 1 and 2, respectively.

Student attitude survey and interview. A 14-item attitude survey was administered to ACOT students to assess their reactions toward their writing experiences. The items consisted of statements to which levels of agreement or disagreement were indicated on a five-point Likert-type scale (5= "strongly agree"; 1= "strongly disagree"). Topics covered included keyboarding, word-processing, electronic mail, and interactions with tutors. Students also participated in a 5- to 10-minute interview regarding their experiences with ACOT and the writing component.

Tutor survey and interview. A survey consisting of seven open-ended questions was administered to the 10 tutors to assess their perspectives of ACOT writing activities, specifically in reference to the electronic mail component. Questions concerned (a) students' writing skills and achievement, (b) the strengths and weaknesses of the program for teaching and promoting writing, (c) tutors' contributions to improving writing, (d) tutors' preparation for their assigned activities, (e) the appropriateness of assignments, and (f) suggestions for improvement.

Data Collection Procedure

In January of the school year, three instruments were administered. First, the student attitude survey was administered to students in the classroom. Items were read aloud as students read them silently. Second, a structured interview was conducted with the ACOT teacher and the ACOT coordinator. Third, the first writing sample was obtained from the ACOT and control students. Students wrote the composition in class and submitted it to the experimenter when done. In April, the second writing sample was written by students during a regular class period. Students were also interviewed in person during free periods.

Results

Teacher and Coordinator Interviews

The ACOT classroom teacher was interviewed regarding the nature and perceived effectiveness of the writing experiences. Both were extremely positive about the

word-processing and electronic mail components but at the same time, frustrated by all that needed to be done and the lack of an established activity plan to follow. The teacher described the students' primary uses of the computer as involving the word-processor. Specific writing assignments included essay questions and English compositions assigned for homework. The students did not have any specified free-time to work on the word processor but were allowed "adventure time" after their other assignments were completed to either work on the word processor or on other software. The teacher strongly believed that the word-processor simplified the work of making corrections and improvements which, in turn, improved students' writing skills and interest. The word-processor, overall, was characterized as an "invaluable" tool.

Among the perceived limitations of the program was its lack of carefully planned writing activities to develop writing skills. Another was that not all students appeared to find electronic mail communications appealing and that only the more expressive students used it extensively. There appeared to be some problems in integrating electronic mail effectively with other work due to its newness and experimental nature; also a problem in isolated cases was a "communication gap" between the college student tutors and the sixth-graders. The teacher also expressed interest in having a greater number of CAI writing programs to accommodate individual differences. Although there was much to do in coordinating writing activities with all of the other ACOT and regular teaching responsibilities, little extra work or preparation was needed to implement word-processing (AppleWorks) as a primary writing mode. Every student learned to use the word-processing program for composing and printing drafts within several days of intermittent practice and employed it for nearly all in-class and homework assignments thereafter. Over time, they developed greater skills with special word-processing applications such as centering text, deleting sections of text, numbering pages.

Student Survey

Student survey items assessed reactions to electronic mail communications and to word-processing. Responses generally indicated dissatisfaction with the electronic mail assignments and their helpfulness to writing improvement. Specifically, the majority of students indicated that they: (a) did not understand their tutor's corrections of their work (67% agreement); (b) were receiving little help with their writing skills (65%); and (c) would prefer to use the BBS to write messages to friends rather than to their tutors (76%). Students were almost evenly divided on the questions of whether they preferred being tutored via electronic mail messages over face-to-face tutoring, and whether they preferred reading messages over writing messages (see Ross, Morrison, Smith, & Cleveland, 1989 for a more detailed report).

Reactions to the word-processor were much more positive. All students (100%) indicated that they liked typing their work, and nearly all (92%) preferred doing assignments on the computer rather than by hand. Aspects of word-processing that were identified by students as especially desirable were the editing features, seeing one's work printed out, and typing as opposed to writing by hand.

Tutor Interviews on the Electronic Mail Activities

Strengths and weaknesses of ACOT for developing writing skills. Specific strengths of the electronic mail activities as perceived by the tutors were practice and repetition ($n = 7$), the requirement to communicate through writing

(n = 2), reinforcement of vocabulary and spelling (n = 2), facilitation of editing and improvements (n = 2), and the establishment of favorable contexts for writing (n = 3). Weaknesses were identified as the inability to give adequate feedback on the current BBS system (n = 5) and the lack of structure to the writing activities (n = 4). Other responses noted the difficulty of accessing (n = 3) and communicating over the BBS (n =3), the limited program duration (n = 1) and limited number of assignments (n = 1).

Tutor's personal contribution. Nearly all tutors (n = 7) felt that they failed to make a significant contribution to their tutees' writing skills (for the reasons indicated on the previous question). Several felt that they were somewhat helpful due to providing positive role models and establishing social relationship with their tutees. Despite accomplishing less than was hoped, most of the tutors (78%) felt that they had sufficient background for tutoring. A frequently expressed concern (56%) was the lack of orientation received regarding the students' needs and level of achievement.

Appropriateness of assignments. Approximately half of the tutors felt that all assignments were appropriate, whereas the other half felt that only some of the assignments (e.g., vocabulary exercises) were appropriate. Exercises identified as the most beneficial for improving writing skills were: (a) students writing paragraphs or letters and sending them to tutors, (b) students writing sentences using given vocabulary words or their own selections, (c) students creating stories by sequencing given sentences, (d) students "playing teacher," (e) tutors writing sentences for students from words that students provided, and (f) students rewriting sentences to correct grammar or change meaning. The majority of tutors (n = 6) indicated that the main need was for increased opportunities to practice writing, both in regular classroom assignments and over the BBS.

Writing Samples

Table 1 presents the group means and t-test results for each of the writing skill evaluated in Sample 1. As revealed, significant differences (p < .05) were obtained on four variables. The ACOT students wrote more, used more topic sentences, and had fewer mistakes in using singular and plural verbs. The control students, however, made more appropriate uses of pronouns.

Insert Table 1 about here

Table 2 presents results for writing Sample 2. The ACOT group had significantly (p < .05) fewer errors in spelling, capitalization, punctuation, and subject-verb agreement, and had better overall content. For the latter evaluation, the general impression was that the ACOT letters were more focused in addressing the topic and featured less extraneous information. Such is reflected in the directionally (but not significantly) lower ACOT means on number of words and sentences. ACOT advantages that approximated significance were lower error rates in singular/plural uses and tense shifts. The only identifiable advantage for the non-ACOT group was use of more details in their writing (p < .05).

Discussion

Findings from the present study suggest that high computer access in

classrooms creates opportunities to expand and enhance students' writing skills. Due to the complexity and naturalistic context of the experimental program examined, the results are not conclusive regarding the effectiveness of specific activities. However, interesting insights were provided regarding the strengths and weaknesses of particular writing components as well as desirable directions for the design of future programs in which computers are employed as a writing tool.

Writing Practice in a Computer-Intensive Environment

Similar to the conventional class, ACOT students received in-class instruction on writing and reading skills for approximately 45 minutes hours a day. However, in contrast to the former, they used word-processing for most home and in-class writing assignments.

With regard to integrating computer-based writing into the classroom, a highly positive outcome was the apparent ease with which the mechanics of word-processing were learned so that computer writing was increasingly used as an alternative to manual writing. Although students received initial training on the word-processor, it was brief and restricted to the fundamentals needed to begin experimenting on their own. From that point on, a "learning by doing" orientation, with supplementary group or individual instruction, was used. Much greater difficulty was encountered in implementing computer-specific (i.e., new or unique) applications, specifically electronic mail and writing-oriented CAI, that changed the conventional way that the class and its writing activities were structured. As experience with computer-intensive environments increases, so should the confidence and knowledge base needed to implement more creative and varied activities.

Writing on the BBS

There was a fairly strong consensus among all participant groups that the electronic mail activities were not a significant factor in enhancing formal writing skills. Tutors and teachers perceived the electronic mail as having substantial potential for improving writing attitudes and skills by establishing writing as a natural means of communicating with friends and tutors. Unfortunately, during this initial year of the program, writing activities were constrained by the difficulty of accessing and writing on the BBS. Many students expressed difficulty in understanding the formal writing assignments and the corrections that the tutors made.

Writing Outcomes

The clearest finding in this study emerged from reactions of ACOT students regarding their writing experiences. There was strong agreement that word-processing was enjoyable and helpful to them in completing assignments. Every ACOT student indicated that, if given a choice between a word-processor and paper-and-pencil to write an essay to be graded, they would select the former. The ability to edit easily was identified as the main advantage. Whether writing skills actually improved, however, is not as clear, but with regard to motivational-affective benefits, students were quite convincing in their support for word-processing as a desirable and preferred writing mode. Corroborative evidence for these reactions was provided in the present study by the teacher and coordinator reports, and in related research which showed ACOT students to make extensive use of the word-processor at home (Ross, Smith, Morrison, & O'Dell

1989).

Results of the writing analysis generally favored the ACOT students over the control group. Specifically, on writing Sample #1, the ACOT students wrote longer essays, used more topic sentences, and had fewer mistakes in singular/plural forms. On the Sample #2, they had fewer errors in capitalization, spelling, and subject-verb agreement, and more unity/coherence in their content. Given the inability to rule out the numerous internal validity threats associated with the present design, these results must be viewed cautiously.

Conclusions

Several conclusions were supported regarding the use and impact of computer-based writing activities in the ACOT setting. First, in replicating previous findings (Madian, 1986; Quellmaltz, 1989; Rodriques, 1985), it was found that students very much enjoyed word-processing, especially the ability to edit easily, and preferred it to the paper-and-pencil mode.

Second, given high computer access in school and at home, students employed word-processing routinely for completing writing assignments. In supporting this idea, the present study extends earlier research to contexts in which word-processing is used as a primary mode of writing rather than as an isolated activity practiced for a brief time each day or for a limited period during the school year (see review by Bangert-Drowns, 1989).

Third, this complete integration of word-processing with school work does not appear to require any special preparation for students or teachers, except with the mechanics of the word-processing program. It was interesting to observe how rapidly students learned those mechanics through independent practice and discovery, and how uninhibited they were about experimenting with different procedures compared to the college students whom the authors have taught.

Fourth, the use of electronic mail for exchanging writing messages appears to have potential as a means of developing writing skills but was weakened in the present study by hardware limitations and the absence of a structured activity plan. Activities that directly stimulate and reinforce effective writing, such as having students check each other's work and make editing suggestions (see, e.g., Bruce, et al., 1985) would seem beneficial for such purposes.

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Table 1

Comparisons Between ACOT and Control Writing Sample #1

Variable	ACOT Mean	Control Mean	t value	Probability
No. of words	80.35	53.17	3.12	.004
No. of sentences	6.87	5.21	1.91	.063
Topic sentence[a]	.74	.38	2.64	.011
No. of details	4.91	5.00	-.14	.889
No. of misspellings	3.22	2.13	1.63	.112
No. of fragments	.83	.83	-.02	.99
No. of run-ons	.74	1.08	-1.13	.263
Capitalization error	.65	1.25	-1.50	.142
Punctuation error	3.57	3.67	- .15	.883
Pronoun score[a]	.17	.67	-3.85	.000
Articles error	.61	.42	.60	.551
Singular/plural error	.26	.88	-2.49	.018
Subject/verb error	1.13	.92	.44	.660
Tense shift error	.22	.25	- .21	.832
Redundancy score[a]	.61	.71	-.71	.483
Content[b]	2.87	2.62	1.05	.298

[a]Scores were based on a dichotomous, satisfactory (1) or unsatisfactory (0) system.

[b]Scores were based on a five-point system (5=highest).

Table 2

Comparisons Between ACOT and Control Groups on Writing Sample #2

Variable	ACOT Mean	Control Mean	t-value	Probability
No. of words	91.63	115.70	-1.26	.216
No. of sentences	5.79	7.50	-1.18	.247
Topic sentence[a]	.88	.65	1.74	.091
No. of details	4.08	6.10	-2.12	.045
Correct letter form[a]	.42	.55	- .87	.391
No. of misspellings	2.83	7.05	-2.55	.019
No. of fragments	.88	1.30	- .80	.432
No. of run-ons	.54	1.00	-1.64	.110
Capitalization error	.38	3.30	-2.19	.041
Punctuation error	2.83	5.15	-2.02	.054
Pronoun score[a]	.83	.90	- .64	.524
Article error	.33	.80	-1.36	.186
Singular/Plural error	.67	1.60	-1.73	.096
Subject/verb error	.13	.70	-2.64	.015
Tense shift error	.21	.55	-1.95	.061
Redundancy score[a]	.75	.60	.93	.359
Content[b]	2.96	2.35	2.40	.021

[a]Scores were based on a dichotomous, satisfactory (1) or unsatisfactory (0) system.

[b]Scores were based on a five-point system (5=highest).

Author's Note

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