Computer Spelling Checkers: An Example Cognitive Tool

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Introduction

Mankind has readily developed tools [Salomon, 1993] to aid him/her in the pursuit of alleviating labor and providing for his/her life's needs and desires. From the invention of the wheel and before, the development and use of tools has separated humans from the other animal species. Physical tools (wheels, levers, inclined planes, etc.) and cognitive tools (symbols systems, books, slide rules, etc.) have both supported us in our labors to improve our lives.

Historically, however, it appears as though the acceptance of tools has been more widely achieved in the non-school world than in schools. Thornburg (1993) alludes to this phenomena by describing how a physician from the 19th century would be totally out of place in today's medical community, but, in contrast, a teacher from the 19th century could be placed in a modern classroom and know exactly what to do, implying that current classrooms have not changed much since the 1800's in terms of the most commonly used tools, e.g. blackboards, books, paper and pencils.

Further, it appears as if physical tools have generally been more readily accepted than cognitive tools. For a carpenter to do his/her work, many physical tools are necessary. No one would expect an apprentice carpenter to build a cabinet without these physical tools. Nor would we expect a child who has a physical handicap of poor eyesight to complete his/her schoolwork without the support of corrective lenses. Yet, in school, we often limit students' access to cognitive tools, especially when evaluating them on their learning, e.g. students are encouraged to seek the wisdom contained in a dictionary (a cognitive tool) while learning definitions, pronunciations, and spellings of words, but for the 'test' of their knowledge, a dictionary is forbidden them. Yet, as adults we rely upon cognitive tools in all our tasks. Consider how well Tom Brokaw would present the evening news without a teleprompter? With the recent and current advancements being made in cognitive tools, e.g. computers and supporting software, resistance to the full integration of cognitive tools must be addressed by the educational community.

Research questions

Computer spelling checkers, an integral part of most word processing software, may be considered an example of a cognitive tool. Concern on the part of teachers, parents, and administrators regarding the cognitive effects of early use of spell checkers, as with calculators and word processors themselves, led to this study. The following questions were posed: 1) Identification: How well do students identify misspelled words? 2) Correction: After identification, how well do students correct misspelled words in a document? 3) Correction rate: What is the correction rate, defined as the number of corrected misspellings divided by the number of identified misspellings? 4) Efficiency: How efficient are students at identifying misspellings and making corrections? I defined efficiency to be the number of misspelled words corrected divided by the time, in minutes, spent on the task. 5) Final product: Which treatment factor provides the best overall final product in terms of the fewest spelling errors per total words written? 6) Spelling performance: Over a semester, how well do students learn to spell words which, in their own writings, they misspelled at least once, and subsequently corrected?

Method

From January to June 1993, 49 students in two fourth-grade classes in a town in southeast Michigan participated in this study. To control for teacher effects, within each class, students were randomly assigned to one of four treatment groups: manual (AM), collaborative manual (CM), spell check (ASP), or collaborative spell check (CSP). Analysis of variance of the students' 1992 national percentile spelling sub test scores of the CAT (California Achievement Test) showed no significant differences among the groups (F-value (3.42) = .029, p = .9934). Further, it was noted that both classrooms had similar word processing experiences. Since the beginning of the school year, both classrooms had been completing word processed papers approximately once a week. Most of the students had no formal keyboarding, therefore it was assumed that a certain portion of their spelling errors would be typographical.

The study included three phases: pretesting, treatment, and post testing. In Phase I (pretesting), students were given an oral and a multiple choice spelling test. In addition, the students participated in a practice proofreading session for their particular group using a story I had prewritten for the occasion.

In Phase II (treatment), the students went to the computer lab approximately once a week, either to compose or to transfer documents (stories, poems, letters, reports) onto the word processing program. Once each student had entered his/her document into the computer, it was saved on a diskette for later retrieval. Students in one classroom completed a total of eight documents each, while those in the other classroom completed a total of six documents each, over the nearly six-month course of the treatment. With each document saved on a diskette, each student or pair of students, in the case of the collaborative groups, would join me in the classrooms' quiet room. The student or students were asked to "think out loud" [see & Simon 1984] as they proceeded to identify and correct spelling in their documents, either at the desk in the case of the AM and CM groups, or at the computer in the case of the ASP and CSP groups. As the students worked a video-camcorder captured their actions and voices, and, in the case of the students utilizing the computer, the computer monitor as well.

In Phase III (post testing, students were given the same oral and multiple choice spelling tests as initially. And, in addition, they took an individualized oral spelling test over words they had used and misspelled in their own writings during the treatment phase.

Throughout the study, I aided the students in the computer room when they did their word processing, helping them save their files, encouraging them to spell as best they could when writing, but emphasizing not to worry about spelling errors as such until they did their proofreading in the quiet room with me and/or their partner later in the week.

In addition to the documents composed by the students, I produced four stories containing typical misspelled words obtained in a previous study [see Jinkerson & Baggett 1993] and from earlier writings of the students in this study. Each story contained words that the spell checker would identify as misspelled, as well as words that would be skipped by the spell checker. The first story was used for practice to teach the students how to check their writings for spelling errors. Stories two, three, and four were given to the students during the treatment phase. By including these prewritten stories for students to identify and correct the misspellings, individual student differences in word choice, length of papers, etc. were controlled for this portion of the data.

Analysis

One- and two-factor ANOVAs were used as a basis for answering the research questions. All significant ANOVAs, both one-factor and two-factor, were followed by Scheffé post hocs tests to correct for multiple tests on dependent variables [Winer, 1971]. Since each treatment group can be described in terms of the presence or absence of two kinds of partners, either human or technological, the two-factor ANOVA tests for the main effects of the factors and the interaction between them, while the post hoc Scheffé tests following a significant one-factor ANOVA identify the specific pairs of means that are significantly different among the four treatment groups. Results and discussion of each research question follow focusing primarily upon the differences between manual identification and correction vs. spell checker identification and correction.

Identification. If students cannot identify spelling errors, they cannot correct spelling errors. Therefore, this initial step of identification becomes crucial to the remaining task of correcting spelling errors, and it contributes to the results of some of the other variables, e.g. correction, correction rate, efficiency, and final product.

Typically, in elementary classrooms, teachers circle misspellings in students' writing, thereby identifying for students the spelling errors they have made. The student knows he/she has made an error only when the paper is returned to him/her, and after the teacher has graded it, or at least seen it as a rough draft. The red marks may confirm a student's belief that he/she is a poor speller.

If a goal of education is to foster independent thinking, decision making, and taking responsibility for their own learning, students must be able to proof their work and make corrections before it is turned into the teacher. From the results of this study, it is evident that students cannot do that task alone. The average rate of identification of misspellings for students manually proofing their own writings was only 8.5% or 3.9 words. Yet, the average number of misspellings per student in the AM group over the course of the treatment was 46 words. That means, on average, these students identified only 4 misspelled words, leaving 42 words still unidentified and therefore, uncorrected. As one boy stated, "I know there are lots of spelling mistakes because I am a poor speller, but I don't know which ones are wrong." It would seem that some students perceive their own difficulties very well.

All the students were to write their papers without concern for spelling, to just do the best that they could: they were told they would take care of spelling errors later. During the proofing process, some students in the AM group quickly read through their writing and then announced, "It's all okay. I did it right the first time." In fact, three students in the AM group never identified a single spelling mistake over the whole semester, yet, these same students had misspelled, on average, 17 words. Since these students did not identify mistakes, they also did not correct mistakes. In essence the students were either confident that they wrote all the words correctly the first time, did not take the spelling proofing task seriously, or were so unsure of their spellings that they didn't know which words were right or wrong. Therefore, they made no attempt at all.

With the prewritten stories, the students in the AM group identified 44.4% of the actual misspellings, a statistically significant increase from the 8.5% identified in their own writings, but still significantly lower than any of the other groups for the prewritten stories. Since these stories were not written by the students, we can discount the idea that they knew the words were written correctly the first time, so they may have approached the task more diligently. Further, since I had written the stories, the students may have felt challenged to try harder to identify the mistakes, knowing that I had deliberately make the errors and was trying to stump them. Another possibility, of course, is that the prewritten stories contained a higher proportion of misspelled words that the students already knew how to spell, and therefore they could identify them more easily.

In contrast to both manual groups (AM and CM) identifying 21.5% of their misspellings, the students in the spell checker groups (ASP and CSP) identified 84.2%, a significantly higher proportion (F-value (4.806) = 154.142, $p = <.0001$). A spell checker is designed to identify words (letter strings) in a document that do not match a prescribed list of words in the program's dictionary (word list). Obviously, it does this task relatively well compared to these fourth grade students. Of course, it fails to identify homophones, real-word errors (e.g. "from" for "form", etc.), and words that are not in its list (e.g. proper nouns).

It seems self-evident, given what a spell checker does, that students using a spell checker to aid them in identifying misspellings would identify a larger proportion than students working without a spell checker. Students need help with this difficult step and a spell checker seems to meet this need for a large proportion of misspellings.

Further, the spell checker offers the possibility of doing so immediately after the student has written the paper, and before the teacher has had a chance to see it. If immediate feedback is important, and research indicates that it is [see Kulhavy 1977], it seems reasonable that allowing students to use spell checkers would be welcomed.

Correction. Once students have identified misspellings through whatever method, the next task becomes correcting those identified misspellings. In a typical classroom students often never get to this step. If the teacher circles (identifies) the students' misspellings in a particular paper for the student, a similar, but

more complete [1] task than what the spell checker has done up to this point, then depending upon the requirements of the teacher, the student may be asked to correct those errors, or the paper may be forgotten, and thus the student will never correct those errors, as the class moves on to new assignments. Few teachers take the time to require students to correct the circled misspellings and resubmit the paper with the correct spellings. In fact, some teachers go further that just identifying the misspellings. Instead, they actually supply the correct spelling by writing above the circled word the proper spelling. If teachers do not require students to correct identified misspellings, the chances are that the students will not even look at the circled words only long enough to feel good or bad about the number of red circles. Nothing forces the student to confront those misspellings unless the teacher is diligent about the students making corrections.

In contrast, most spell checkers, when identifying a word as possibly misspelled, stop and force the user to make a decision about how to proceed, that is, whether to ignore it, to retype it, or to ask for suggestions. Of course, the student can make the wrong decision, but at least he/she must acknowledge that for some reason, the spell checker stopped on that word.

As with identification, the students in the two manual groups corrected the lowest proportion of identified words, 17.0%, vs. 50.4% for those students in the two spell checker groups. Adding the spell checker as a technological cognitive partner significantly increased the number of words corrected (F-value (1.379) = 59.791, p = <.0001). Similar results were noted for the prewritten stories, 41.8% vs. 68.3% (F-value (.855) = 38.662, p = <.0001).

A word of caution needs to be addressed in the use of correction by spell checkers. The students in both classes had been studying the environment in relation to "Earth Day" and had learned of the danger of overuse of aerosol spray cans to the ozone layer. Consequently, in the final prewritten story, I included a misspelling, "aresal" for "aerosol." The spell checker did not offer the correct spelling, instead it offered only one option, "arousal." All but one student in the spell checker groups immediately selected "arousal" to replace my misspelling of "aerosol." Students must be very aware that just because the spell checker offers only one option, that is not necessarily the correct one. Just as with calculators, students must be taught to develop critical questioning skills when working with spell checkers and not just blindly accept the solution offered.

Another observation noted in the identification and, subsequently, the correction process was the students' knowledge of words not studied through school spelling lessons. In the final prewritten story, I inserted the incorrect spelling "nintindo" for "Nintendo." Over 80% of all the students in all groups identified and corrected this misspelling. This raises questions about incidental learning of correct spellings versus learning correct spellings through traditional school spelling lessons.

Correction rate. The correction rate provides evidence as to how well the spell checker as a technological cognitive partner aids the student in correcting errors that have been identified. Students in the AM group were able to correct approximately 55% of the words they identified as misspellings in their own papers and approximately 65% of the identified words in the prewritten stories. It is interesting to note that the addition of a technological cognitive partner, the spell checker, did not significantly alter the students's rate of correction after identification (Correction rates of 66.1% and 74.6%, respectively, for students in the spell checker groups for their own stories and the prewritten stories.) Overall for all groups and all documents, correction rates averaged 69%. It appears that the spell checker does not aid students in correction rates, that no matter what method of correction is used, students can correct misspellings that have been identified as misspellings approximately 70% of the time. This supports the results reported in Jinkerson & Baggett's previous work (1993).

Efficiency. Efficiency is often used as a measure to ascertain whether one method of completing a job is preferable to another in terms of the amount of work done per unit of time. As elsewhere, time is a precious resource in schools. If students spend an inordinate amount of time on one task, the amount of time of remaining tasks becomes short-changed. It becomes important for students to work within a reasonable time allotment. When efficiency of correcting misspellings is evaluated in this study, students with a spell checker correct more words per minute than do students correcting manually. This fact is

[1] More complete in that a spell checker does not identify homophones, real-word errors, grammatical errors, etc. whereas a teacher, of course, would identify all types of spelling errors.

especially evident when comparing the AM with the ASP groups, where the ASP group corrects over four times as many words per minute as the AM group (.432 vs .100 words corrected per minute for ASP vs. AM groups respectively). Overall, students working with a spell checker have significantly higher efficiency ratios than those working manually (F-value (.406) = .15.656, p = <.001).

Relating to efficiency, for some students using the spell checker an interesting observation was noted. If a word was identified as suspect, for example, "invirnment", and the spell checker failed to offer the correct alternative, "environment". to the student in the list of suggested spellings, the student would return to the 'retype the word' option of the spell checker and type another spelling of "environment." Often the student was aware that the new spelling he/she typed was still incorrect, but by entering a different string or configuration of the characters, the spell checker would be able to offer different suggested spellings. A few diligent students would work back and forth in this manner several times trying to get the spell checker to provide the correct spelling. Obviously, this use of the spell checker took more time, thereby possibly decreasing the student's efficiency than manual or even traditional spell checker methods. Yet, it demonstrates the extent that the spell checker can become a real cognitive tool to the student.

Another observation made of a few students in the spell checker groups was a general interest in and playing with the spell checker. For example, a few students deliberately misspelled a word just to see what the spell checker would suggest. It became a game to them to stump the spell checker. A couple of students went so far as to just enter a string of letter and then ask the spell checker if those letters comprised a real word spelling. Obviously, this activity added to the time on task for identifying and correcting errors and consequently distorted the "real" efficiency. Yet, I believe it was valuable experimenting and should be promoted as a method of word exploration. I can't recall ever observing a student write a word on paper and then to go a dictionary to look it up to see if it was a real word. If teachers are interested in students' vocabulary development, 'word play' such as observed here should be encouraged.

Final product. The results demonstrated that there were no significant differences in the proportion of total words correctly spelled in each student's original papers (overall, approximately 7.8% words misspelled). After correction, however, there was a significant difference in the proportion of total words correctly spelled in the students' final papers for the main effect of manual vs. spell checker (F-value (.018) = 8.477, p = <.01).. Students correcting their papers with a spell checker end up with a final product containing significantly fewer spelling errors that those who correct their papers manually (6.9% misspellings in final products vs. 3.4% for spell checker groups). Similar results were observed with the prewritten stories where students correcting manually had 9.9% misspellings in the final versions while those correcting with the spell checker had only 5.4% (F-value (.025) = 38.662, p = <.0001).

Spelling performance. While no statistically significant results were noted in the students' personalized post-treatment oral spelling tests that would allow for generalizations to be made to other populations, a practical difference was noted in the results with this particular group of students. Out of a possible 10 points, the students in the AM group scored, on average, 4.25 correct. The students in the CM group scored, on average, 5.17 correct. The students in the ASP group scored, on average, 5.31 correct. And, the students in the CSP group scored, on average, 6.25 correct. Thus, the teachers in this study should value the 9% to 20% increase in their student's score. Using practical results as the criteria then, again, for this particular group of students, it appears that using a spell checker to identify and correct misspelling, students learn to spell those words correctly more often than students who manually identify and correct misspellings.

Conclusion

Overall, the students in the two spell checker groups (ASP and CSP) outperformed the students with no technology partner. They identified and corrected a higher percentage of both their own misspellings and those in the prewritten stories. Hence, their final products were freer of spelling errors. Furthermore, the students utilizing a spell checker identified and corrected more words per minute than those manually correcting spelling. Correction rates, however, were not significantly different among the groups. Finally, although no significant differences were found in the students personalized post-treatment oral spelling

tests, practical differences were noted, a 9% to 20% increase in scores over those in the AM group. These results add computer spelling checkers to the growing cadre of technological cognitive tools students and adults can and should use on a regular basis in the completion of their work.

With cognitive technologies such as computers and supporting software, including spelling checkers, "...the technology is encountered, engaged. It becomes something to master, defeat, learn from, or take advice from." [see Howard 1994] (p. 395) This supports Perkins' (1993) "person-plus" system, Pea's (1993) concept of tools as indispensable instruments of mentality, as well as Salomon, Perkins, and Globerson's (1991) "partners in cognition" model. On an analytical level, the user is well aware that he/she is interacting with a machine, not a human being, but during the actual interactions with the machine, the user may sense being in communication with the machine much like communication with another human (see Howard in press). Thus, the technology mediates students' lives, and has implications for both pedagogy and the curriculum.

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