12

Microcomputer-Based Environments for Writing: A Writer's Assistant

James A. Levin
Marcia J. Boruta
Mary T. Vasconcellos

INTRODUCTION

How does one become an expert writer? Recent work on problem solving (Chi, Feltovich, & Glaser, 1981; Larkin, McDermott, Simon, & Simon, 1980) has shown that expert solvers of physics problems bring several different organizations to bear on these tasks, initially applying more global qualitative analyses, then moving toward more detailed quantitative expressions. The qualitative conceptual organizations of the task guide experts through the details of the local quantitative analysis, allowing them to solve the problem quickly. Novices, on the other hand, only have the more local level of analysis, and start writing equations, getting lost in the details because they lack the overall organization.

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Send request for reprints to J. A. Levin, LCHC (D-003), UCSD, La Jolla, CA 92093.

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This difference between novices and experts has a direct analogy in the writing domain: experts appear to the uninitiated to start by writing words, yet novices who do so quickly get lost in the details, producing muddled text. An expert writer differs from a novice by operating at several different levels, both global and local, while a novice writer, like the novice physics problem solvers, can operate only at a few local levels.

We have been conducting research into the nature of writing expertise and its acquisition. Our approach has drawn upon the cognitive science framework for writing developed by Bruce, Collins, Rubin, and Gentner (1982). Within this framework, writing is a communicative action that results from multiple cognitive processes that operate simultaneously, producing text through their interaction. For example, there are processes that draw a letter on paper, those that select words and order them in sentences, and those that generate, select, and organize ideas. While an expert writer can operate competently on these many levels, a novice tends to become locked into the more local levels, a phenomena called *downsliding* by Bruce *et al.*

The concept of dynamic support for writing is central to our work. We have been constructing microcomputer-based environments for writing that provide tools that assist at different levels in the writing process. These environments serve both as powerful research settings for investigating the multiple processes of writing, and as teaching techniques for helping novice writers acquire expertise. One of these environments is a word processor program that people can use to generate and modify their own text, which we call a Writer's Assistant.[1] The writer types the text into a microcomputer and the text is displayed on a video screen. When the computer is attached to a printer, the writer can easily produce a printed copy. This system is simple enough that elementary school children have quickly learned to use it to create and modify text of different sorts.

The Writer's Assistant is a powerful tool for research on the writing processes. It serves as a data collection device, since it keeps a detailed "trace" of the keystroke actions taken by a writer in generating and changing the text. We have been using these trace data to study the processes involved in writing. For example, two boys, Gerry and James, used the Writer's Assistant to create a story they named "Dragon Tamer." We have used their data to analyze relatively low-level processes, such as spelling or typing correction. For example, in one case, Gerry and James changes sour to sor~~cer~~ to sorcery.

[1]The Writer's Assistant program has been written in UCSD-Pascal by Jose Vasconcellos. It is based on an early version of the UCSD-Pascal Screen Editor. Thanks to Dr. Kenneth Bowles and the members of the UCSD-Pascal Project for their assistance.

Data from the Writer's Assistant also show indications of higher-level, more global actions. The Writer's Assistant keeps track of large-scale deletion of previously entered text, as well as insertion of new text. For example, in the story described above, the title of the story initially was "Dragon Slayer." At the very end of their writing process, the boys deleted that title, and replaced it with "Dragon Tamer." This title change reflects a major thematic modification that the boys made halfway through their story. They had described the king's promise as "whoever slayed the dragon would get his daughter's hand in marrige, and riches beyond imagination." They then went back and inserted after "slayed" the phrase "or tamed." From this, we can infer that they had decided at this point to end the story with the hero taming the dragon and claiming his reward rather than the conventional, more violent ending.

To complement these keystroke data, we have conducted detailed field observations of children using this system in the classroom. The keystroke data files tell what was typed in what order; the field notes tell who did the typing and what interactions occurred during the course of the writing. With this information we have begun to look at the progression to expertise in writing.

A second major function of the Writer's Assistant for our research is to allow us to provide differing amounts of support in different areas to novice writers. By observing their writing actions, given selected kinds of support, we can start to disentangle the complex interactions among the multiple processes that constitute writing. This use of microcomputer-based writing environments is similar to an approach to educational evaluation called "dynamic assessment" (Brown & Ferrara, 1982; Feuerstein, 1979), which measures ability or knowledge in terms of the amount of help needed by the subject in order to solve a problem successfully.

DYNAMIC SUPPORT FOR WRITING

Support is provided by any resources external to a person that contribute to the accomplishment of a task. Dynamic support is support that allows a novice to accomplish a task, but which is progressively withdrawn as the person acquires expertise. In the domain of writing, our aim has been to provide sufficient support to allow novices to accomplish writing tasks that serve the novices' own goals. For novices, much of the effort of writing is distributed externally, both over other people in the setting and over inanimate resources, such as print and computers. As the novice writer becomes an expert, this external support becomes less necessary, as more of the cognitive processing can be done by the writer. Our goal in designing microcomputer-based environments for writing has been to create settings in which the support provided by the environment can be reduced dynamically as the writer progresses to expertise.

A Classroom Electronic Newspaper

In our work with a third–fourth grade classroom during the spring of 1981, we focused the writing activities of the children by using an Apple II computer to create classroom newspapers. The newspaper text file was structured into different sections (news, sports, TV reviews, cookbook, jokes, etc.). The students worked on each issue of the newspaper over the course of a month, adding new stories and modifying existing ones. Then the paper was printed out and distributed. We provided dynamic support within this writing environment in several ways. Some sections of the newspaper provided considerable structure, requiring only that the children fill in the blanks, in a sort of computerized "mad-lib." For example, one story form was:

ONCE A ##### WAS ##### IN A #####.
HE TRIED TO GET ##### THROUGH THE #####.
HE ##### WITH ##### AND #####, BUT HE #####.

One child filled in these blanks to produce the following little "story":

ONCE A FROG WAS IN A POND .HE
WANTED TO SEE THE WORLD . HE TRIED TO
GET THROUGH THE CAGE . HE TRIED
WITH ALL HIS MIGHT , BUT HE CHOULDN'T.

A pair of children, Taffy and Edwin, filled in the blanks in the first sentence, then finished the story in a completely different way. This writing environment, unlike paper and pencil worksheets, allows them easily to go beyond the support provided.

ONCE AN APPLE WAS COMPUTER IN A
CLASSROOM. SHE HELPED TEACH CHILDREN
HOW TO SAY SOMETHING. ONE DAY THE
COMPUTER BROKE DOWN BECAUSE SHE HAD
NO CHILDREN TO TEACH. THE CHILDREN
CAME BACK AND PUT A BANDAGE ON HER

SCREEN. THE COMPUTER FELT BETTER AND
BEGIN TEACHING AGAIN. THE CLASS LIVED
HAPPILY EVER AFTER.

Other sections provided partial support: A story was started but left for students to finish, or a question was posed and students inserted their own replies. For instance, in a "Letters to the Editor" section, the question was posed, "How is writing with the computer different from writing with pencil and paper?" Various groups of students supplied various answers: "Because its funner and easier than writing with pencil and paper. Also it does not hurt your hand." responded Jane and Mary.

In some sections, just the section header was supplied ("Weather") and students started new stories with this minimal support. Even in these cases, there quickly arose social/computer support in the form of other students' articles in these sections. One weather report started "Today is May 9, 1981. It is really nice out. The sky is clear, and there are very few clouds. . . . " The next article, by Taffy and Alice, went: "Today is June 5, 1981. It's cloudy today . The temperture is 72 deegres. The grass is dewy . It might rain. One reason I think so is because a class did an Indian rain dance."

The newspaper file thus contained sections that varied in the amount of support they provided to writers, from substantial support to minimal support. The children were allowed to select which section to work on during their writing time, and most of the children worked on several different sections during the school year. Some children moved beyond even the minimal level of support provided by the "section header" support, creating totally new text files that started with a blank screen.

The Writer's Assistant

The Writer's Assistant itself provided substantial support for writing. It is a "screen" editor, and thus follows the general principle of "what you see (on the screen) is what you get (when you print it out)." When changes in the text are made, the text on the screen is correct. There are no erasure marks, no crossed out sections, no squashed insertions. The cost of correcting errors or making changes is lowered so that students easily can create "perfect" text. Papert, Watt, diSessa, and Weir (1979) describe a "learning-disabled" girl who had great difficulty writing with paper and pencil. She was able to write much more fluently when given the opportunity to create error-free text. Whenever she did make an error with the "line" editor she was using, she pushed the RETURN key until the error scrolled off the screen. The ability to create perfect text was cited by our novice writers as a great advantage over pencil and paper. In the "Letters to the Editor" section of the class newspaper, the question was posed, "How is writing with the computer different from writing with pencil and paper?" One response entered by two fourth-graders went, "You can write faster and better. You also don't need to erace." Another pair of writers concurred: "Because you can go faster on the computer. Also you don,t have to use pencil and paper and you don,t have to erase mistakes you make."

The Writer's Assistant, like many computer editors or word processors, has two ways of deleting text. One way is with a "Drop" command, which allows text to be deleted anywhere in the text. The other way is with a single character erase key, which can be used while entering new text. This "local" deletion is most often used to erase a single character just typed, because to delete previous characters requires also deleting all the intervening ones as well.

The Writer's Assistant also provides a set of other commands, some standard for computer text editors and others specially tailored for helping elementary school children enter and modify text. As with most other text editors, the Writer's Assistant provides ways to move through the text, either letter by letter, line by line, or screenful by screenful. The Writer's Assistant also provides ways to find a particular pattern of characters in a text, to replace systematically specified characters with others, and to move blocks of text.

We provided the children with some special commands to help them write. These included a command to carry out spelling verification of a selected word, a command to rearrange text by putting it into either paragraph format or individual sentence format, and a command to allow writers to try out combinations of words or phrases systematically. Because the Writer's Assistant was designed especially for the beginning writer, a "Help" command was added to the program, which provided information about how to use the commands.

The special command that was used most frequently by the students was the spelling verification command. To use this command, the writer moves the cursor over a word and asks for verification. The Writer's Assistant searches a spelling file, attempting to make a phonetic match. If a match is found, the word is presented to the writer, along with a short definition. If the writer doesn't accept the suggested word, then the search continues, until the spelling file is exhausted. With this approach to spelling correction, the writer has first to make a guess at the correct spelling of a word, then immediately receives feedback about that guess.

Social Support for Writing

Social support for writing was provided in several important ways. The use of the computer in the classroom we worked in went very smoothly, largely because the class was organized into "centers" among which pairs of students rotated, during three days each week. This same classroom was run on a "whole class" basis two days a week, so we were able to see repeatedly that the uses of microcomputers described here were much more compatible with a "center" organization than with a "whole class" organization. The other advantage of the "center" organization is that it provided a natural way to allocate turns on the one computer in the classroom to students, in a way that each student could understand and anticipate. Also, it made computer use an integral part of the classroom curriculum.

It was crucially important that pairs of children used the computer at a given time. From the point of view of the teacher, the demand upon his resources was substantially reduced, as most of the problems that arose for one student could almost immediately be handled by the other student. Quinsaat (1981) describes in detail the advantages of having pairs of children use the computer in a classroom. In contrast to the stereotype that computer use leads to isolation of students from their peers, this paired student use generates substantially increased interaction between peers, compared with other classroom activities. The interactions are most often cooperative interactions, with mutual benefit to both students in dividing up the task at hand. For research purposes, having pairs of children use the computer generates ecologically valid "protocols" of the children's writing processes, as each child explains to the other what actions to take and reasons for those actions when there is a conflict.

Because many of the trivial problems could be handled by the students themselves, the teacher was able to allocate his time to the computer writing center in a more fruitful way, providing different kinds of support tailored to the needs of the students. For some relatively expert students, he assigned them to the center without further involvement on his part. For other students, he would suggest a writing task to work on at the beginning, allowing them to work on this task by themselves. For more novice writers, he would spend his time with the pair, providing overall direction, while leaving the details to be worked out by the students. For total novices, he would actively elicit the contents of the newspaper stories, and sometimes even type the stories in. Thus, he was providing very dynamic support, in exactly the way that teachers have always provided such support to the extent allowed by the organizational limitations of their classrooms.

Dynamic support was also provided by the sequence in which the teacher introduced the computer and the Writer's Assistant. In our work with a classroom in the spring of 1981, the teacher introduced the children to the computer through the use of a Typing Tutor program, which helped them to learn the location of the letters on the keyboard. Next, they used a Story Maker program (Rubin, 1980) to generate and print out a number of stories. The Writer's Assistant was then introduced, with the children given simple "fill-in-the-blank" exercises that only required using the basic commands. Finally, the children learned to carry out the full range of text generation and manipulation, as new commands were introduced in the context of less-structured exercises within the class newspaper activity.

The same teacher ran two summer school classes, each of which only extended over 2 weeks. In these classes, the teacher bypassed using the typing tutor, starting immediately with the storymaker program and the Writer's Assistant. There was a wider range of ages in these classes, with the older children quickly mastering the Writer's Assistant and entering completely new stories, younger children working within the more supportive frame of the newspaper file, and the youngest children continuing to work with the Story Maker program.

EXPLORATORY ANALYSIS OF WRITING PROCESSES

We present here some preliminary analyses of pilot data collected in the initial stages of our study of problem solving while writing, using the microcomputer-based environments described above during the spring of 1981. Our work in this area is ongoing; we worked with the same teacher during the fall of 1981, and continued the study through the winter and spring of 1982, collecting data of the use of these writing tools during a full school year. Our preliminary data are presented here to illustrate some of the ways we have tried to integrate keystroke data with field observation in order to shed light on the multiple interacting processes involved in writing.

Analysis of Problem-Solving Episodes

By using both keystroke data and field observation notes, we have been able to analyze episodes in which writers have encountered and solved problems in writing. In this context, a problem is defined as a situation in which people are unable to reach some goal after repeated attempts (Hutchins & Levin, 1981). Writers can be "blocked" at any of the multiple levels of processing involved in writing.

The "block" to writing may occur at relatively low levels. For example, two boys, Howie and Sam, were entering into the class newspaper a review of a book called "Charlie and the Chocolate Factory." They were just finishing the first part of the review: ". . . Then the mother said who is going to take C~~ah~~harlie to the chocolate factory." Howie started the next sentence: ~~g~~Granpa ~~g~~Gorge said ~~I~~I/~~wil~~'. Looking around for the apostrophe key, so he could type *I'll,* he pressed *7,* the key, which when shifted, gives the apostrophe. They erased that and tried holding down the CTRL key and typing *7,* then holding down the ESC and 7 keys. After repeated attempts to solve this low-level problem, they selected an alternative action, perhaps less satisfactory on its own merits, but "satisficing" in that they could proceed with the overall task. Finally, Sam said, "Just type *I will.*" Howie typed, "I will take him."

This episode illustrates the benefits of having pairs of children use a computer together, both for research and for learning. Often, when one child encounters a block in writing, the other child, bringing a different point of view, can solve the problem by suggesting an alternative approach. The first child not only benefits from having the immediate problem solved, but is exposed to alternative ways to think about the task. Taking a different "point of view" can often lead to breaking through a problem-solving block (Hutchins & Levin, 1981).

The interaction in this "apostrophe" episode was characteristic of the ways these boys interacted while writing, and was also common among other pairs of children we observed. These boys did not strictly divide the task into components at the same level, a division of labor which we observed in other kinds of computer use (Levin & Kareev, 1980). We have seen two kinds of peer-level division of labor: some children divide the task into long alternating turns with little participation when it is not their turn; other children alternate at much shorter time intervals (for example, sharing the typing of a single word). These two boys participated simultaneously but at different levels. One took prime responsibility for entering text, and the other participated at a more global level, suggesting what to say. The "typer," however, took an active role in the composition process, as he didn't always follow suggestions, but instead would type something different or would stop to discuss what should be said.

By combining both keystroke data and field observation notes, we have been able to identify some of the ways that children can deal with "blocks" to writing. Although the keystroke data show precisely what actions were ultimately taken, the field observations add rich detail of who took those actions, what discussion and nonverbal interaction preceeded the actions, and the manner in which the actions were taken.

Analysis of Deletion Episodes

We have analyzed the keystroke data of children's work with the Writer's Assistant to produce a classification of the episodes of deletions. Most of the deletions occur during "local editing." This is the use of the single character delete key while entering new text.

Most of the local deletion episodes are singlets: 56% of the 141 episodes in the Dragon Tamer story, for instance, were isolated, single-letter deletions. The remaining multiple, adjacent deletions followed one of the following patterns: total replacement (~~in~~ → at), partial replacement (~~in~~ → on), and overdeletion (~~in~~ → if). We classified the cases of local deletion made during an insertion into the following categories: (1) capitalization (a letter is replaced by the same letter of the opposite case); (2) correction of spelling or typing errors (one or more letters in a word are changed, while other letters are retained); (3) punctuation and spacing (adding or deleting periods or spaces, changing periods to commas, adding commas); (4) correcting verb tense (ending of verb deleted, different ending added); (5) word choice (all the letters of a word are deleted and another word is entered); and (6) adding omitted words (words are deleted, a word added, then the deleted words reentered).

Major structural changes were carried out by using the separate deletion command. By comparing what is deleted and what is then inserted, we have evidence of the level of text organization the writer is concentrating on at that moment. For example, the data can provide an indication that the writer is "downsliding" at that point, focusing on the local details of word selection and spelling, and ignoring the large-scale organizational issues (Collins & Gentner, 1979).

Global Evaluation of Impact

At the beginning and at the end of the use of the Writer's Assistant during the spring of 1981, children in the experimental class and in a control class wrote on a topic using paper and pencil. The students generated these pre- and post-computer-use writing samples under instruction to do the best they could in the time given. No other help was given by the teacher. We have analyzed these samples with respect to two measures: (1) length of samples, in number of words, and (2) overall quality of the samples, using a holistic rating on a four-point scale. Our analysis of these data indicates a significant change in the writing of the children in the experimental class.

We found an increase of 64% in the number of words in the prompted

writing of the experimental class after working for 4 months with the microcomputer writing environments, increasing from an average length of 45.1 words per sample to 74.1 words per sample. The control classrooms showed no increase in average length in their prompted writing samples (pre = 44.6; post = 46.4).

The quality rating was based on a four-point scale, with the judge blind to the classroom from which the samples belonged.[2] The judgments were "holistic," with adherence to topic and organization emphasized. The mechanics of spelling and punctuation were deemphasized. The qualitative score for the experimental class increased from 2.00 to 3.09 after the 4-month period in which they were using the Writer's Assistant. The control classrooms had a pre-experiment score of 2.27 and a post-experiment score of 2.24.

ONGOING WORK

Our computer-based environments for writing have been constructed to provide us with data on the cognitive processes involved at different points in the multilevel interacting complex that comprises writing. We are extending the current work in three main directions: (1) development of an interpreter of interactive text; (2) construction of an electronic message system; and (3) the implementation of various writing simulation games. Each of these directions will give us powerful new ways to collect data on writing processes at different levels.

Interactive Text

One new direction is developing environments in which writers can create and modify interactive text. This is text for which the writer builds in alternative choices that the reader can take. A reader interacts with a computer program that displays text and presents alternatives from which a reader can select. The text displayed after a reader makes a choice is an interactive product of the alternatives provided by the writer and the selection made by the reader. (The writer and the reader may be the same person at different times, or different people.)

This interactive text interpreter allows a writer to structure text in various ways for readers. For example, the writer can provide an initial table of

[2] Our thanks to Marilyn Quinsaat for performing the holistic scoring of the writing samples.

contents, where a choice takes the reader automatically to the selected section. Or the writer can create a "story world," within which the reader can explore creating his or her own particular story. The concept of interactive text was foreshadowed by the Story Maker programs developed by Rubin (1980; Chapter 11, this volume). A "Dungeon Master" in a *Dungeons & Dragons* game could use this interactive text mechanism as a sort of "Dungeon Master's Assistant," which presents the descriptions of the parts of the dungeon occupied by the players.

For research purposes, this interactive text interpreter will help us gather data on larger-scale text organization, as writers will be encouraged to build these units into their interactive texts. By observing detailed data on creation and modification of the various text units in an interactive text, we will have much richer data on the higher-level organization of writing.

Electronic Message Systems

One of the main foci of our research (and a second direction) has been on the role that external resources play in writing and in the acquisition of writing expertise. We have been working with Ron and Suzanne Scollon of the University of Alaska, Fairbanks, to develop a system using microcomputers in classrooms that will allow children in San Diego to send and receive electronic messages from children in Alaska. This exchange of messages gives us yet another way to bring social resources to the educational setting, broadening the range of peers available for children to draw upon for learning and problem solving. Microcomputer electronic message systems have tremendous implications for education, especially education in remote isolated areas, as they open up an immensely wider range of resources to previously limited educational settings.

Writing Game Worlds

A third direction is to develop various kinds of educational computer games that involve aspects of writing. "Adventure" worlds, in which the characters are words or letters, mystery games in which the secret lies buried in the "deep" structure of text, or action games for which the correct sequence of actions generates a message, are some examples we have been developing. For example, we have worked out the initial structure for a "word market" communication game (which would use the electronic message system described above). In this game, each player starts out owning

certain words, and can communicate only using those words. However, a player can bargain with other players, trading surplus words for words needed to communicate.

SUMMARY

We started by constructing various kinds of dynamically supportive environments for writing, so that we could gather detailed data about the processes involved in writing, especially when writing problems occur. By using both keystroke data collected by the Writer's Assistant program and ethnographic notes collected by field observation, we have examined some aspects of writing expertise and the acquisition of these skills.

Many of the constructs of problem-solving research can be used to characterize expertise and problem-solving abilities in writing. Recent research on problem solving, especially in solving scientific problems, has focused on the multilevel representations that experts bring to bear in tackling problems. Other research on problem solving in everyday settings has pointed to the critical importance of external resources (Levin, 1981). The parallel between the Gestalt notion of "being blocked" in problem solving and the notion of "writer's block" is obvious. The power of the analogy is that it suggests using the construct of "conceptual reorganization" from the problem-solving domain for instructing writers on how to overcome writing blocks.

Our current efforts are focused on ways to construct writing environments that allow us to collect richer data on the writing processes. These data will, we hope, allow us to address more fully the issue of multiple levels of processing, the rich ways of using external resources, and the progressive acquisition of skills initially supplied by external resources in becoming an expert writer.

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Author Index

Numbers in italics show the page on which the complete reference is cited.