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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Centre for Educational Research and Innovation

NEW INFORMATION TECHNOLOGIES AND BASIC SKILLS

Working Group 2: Writing: Functional and Creative

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0. INTRODUCTION

1. We are in the midst of not one, but two, revolutions in education. The first exemplified by the present OECD project, concerns the impact of New Information Technologies on teaching and on our understanding of the learning process. The second, one which seems at first to be far removed from

the realm of NIT, is a radical reconception of the role of writing [by which we mean "written expression", not handwriting] in education and of how it should be taught.

2. This report, one of four on NIT and Education, focuses on the confluence of these two revolutions. Despite initial impressions to the contrary, we suspect that NIT may have a great, if not their greatest, impact in the area of writing.

A. New Information Technologies

3. The general outlines of the NIT revolution are already evident. We see computers and allied information and communication technologies as making possible significant advances in several areas. First, the computer as a tool becomes an aid to all aspects of learning by doing. In the area of writing, especially, computers facilitate learning by fostering success and making the task more meaningful. Second, NIT provide new environments for learning, e.g., communication networks foster writing with clear purposes to real audiences. Third, NIT make language itself an explorable domain. Students can discover for themselves the patterns of language through games, simulations, and constructive activities. Fourth, there is now the promise of not just machine-based or programmed teaching, but truly Intelligent Tutoring Systems. Fifth, NIT make research on learning more feasible and teaching better informed by making the learning process more visible. Sixth, and finally, NIT are changing our conception of what needs to be learned. Facility in the use of new information processing tools is becoming an increasingly important aspect of what it means to be skilled in a given area.

4. These are exciting possibilities for the near future, but the hopes for what NIT can do for teaching and learning must be tempered by the realities of present-day educational systems. We must critically examine the promise in the light of what we know about educational expenditures and equality of access. Moreover, we need to understand better how NIT can actually be incorporated into existing schools. These issues as well as the existing promise, must be seriously studied.

B. New Perspectives on Writing

5. Coincident with the rise in the use of NIT for education has been a rethinking of writing instruction. Writing is increasingly being seen as a tool for acquiring knowledge, for developing thinking and for real communication. At the same time, conventional methods of teaching writing, which have emphasized grammar drills, formal presentations by the teacher, and detailed editing of student products, are giving way to approaches that emphasize significant interactions between reading, writing, speaking, and listening; a focus on meaningful communication with real audiences; and ample opportunities for feedback and revision in a non-linear writing process.

6. This shift in the teaching of writing has been fostered by extensive research on writing in recent years (Hillocks, 1986), which has challenged the assumptions underlying conventional approaches. The research has tended to stress one of two perspectives: (1) writing as a social act, as a basic skill for learning and survival in a literate society, and (2) writing as a cognitive act, as a tool of thought. Neither of these strands support the traditional focus on mechanics per se (grammar spelling, punctuation, capitalization, etc) nor, the exclusive use of the writing assignment a task usually

separated from all other aspects of learning.

7. When writing is viewed from the social perspective, understanding the purpose and the audience become paramount (Bruce, Collins, Rubin, & Gentner, 1982). In all writing situations the basic goal of writing is to convey some message to the reader. The message is the writer's point of view about the topic which, in turn, may vary according to the writer's purposes, whether that be to inform, to persuade, or to express feelings.

8. The writer produces a text without the direct cooperation of the reader. This distinguishes writing from face-to-face conversational interaction. Since a writer cannot have immediate feedback, the text has to anticipate and address possible responses (e.g., lack of interest, comprehension difficulties, memory difficulties, objections, criticisms). Extending Grice's (1975) notion of the co-operative principle for conversations to writing, we can say that the writer and reader are bound by mutual obligations: The writer is obligated to write a clear text, while it is the reader's task to read the text and interpret it with due regard to the writer's presumed purpose.

9. At the same time, the social perspective leads us to see the production of text as a typically collaborative act. Most adult writing is embedded in social settings. Expert writers are therefore not just expert at putting words to paper, but at listening to others, interviewing, discussing, arguing, analyzing, synthesizing, and, generally, engaging in collective as well as solitary intellectual work. Questions need to be raised: How are these skills learned? How well do schools prepare students for writing in adult contexts?

10. When writing is viewed from a cognitive perspective, it appears as an immensely complex act, one essentially inseparable from general thinking and learning (Gregg & Steinberg, 1980). From the cognitive perspective, understanding of the writing process becomes paramount. During the writing process writers must generate and collect ideas, then organize, prune, and revise them. Moreover, they must produce text with attention to all levels from individual word choice to overall text organization. To complicate things, text production and idea generation are not easily separable, for ideas arise during the process of creating text.

11. What makes a person a good writer, or even an adequate one? In simplest terms, good writers (in a given domain) know more -- more words, more ways of expressing ideas, more forms of text organization; they are also more skilled at applying the knowledge they have; and, they have better strategies for putting everything together, even going beyond what they know. It is this third capability, having strategic skills, that brings the cognitive and social perspectives together. Expert writers are members of the world of written communication who have experience in various kinds of writing situations: They have written on a variety of tasks and topics for varied writing purposes and audiences. As we examine new technologies for teaching writing we will need to keep in mind these aspects of writing expertise.

C. New Information Technologies and Writing Instruction

12. Technology can be used to change writing instruction in a variety of ways. Computers can aid at places where teacher time and attention are insufficient. They can make prewriting activities more

feasible, in particular, they can stimulate the processes of generating ideas and organizing text. Unlike teachers, they can give feedback at any convenient moment. They can comment upon features of written texts. With the aid of a text editor, revision of text is highly efficient and more rewarding. Most importantly, computers can provide new opportunities for the introduction of effective teaching strategies.

13. Computers can increase the time-on-task and can help lessen the teaching load. They can thus create time and opportunity for teacher involvement with essential aspects of writing processes that are beyond the reach of the computer.

14. New technologies can also help to realize a more functional way of teaching writing. Ideals of writing across the curriculum may become more feasible with the support of computers. By means of computer networking, communities of student-writers can be established. Real audiences and meaningful goals can stimulate the development of competency in written communication as well as enhance motivation.

15. With the aid of computers, students can access knowledge bases that contain information on spelling, punctuation, grammar, and style, but also factual data, and models of texts and the writing process. Texts written by students can easily be be stored and retrieved later in order to analyze errors and growth in writing. Aspects of the writing process itself can also be made visible to the learner and the teacher.

D. Outline of the Report

16. In this report we examine the teaching of writing, new technologies of today and the future, implications for education, and recommendations to bring about significant and cost effective change in writing instruction.

Section I discusses the pedagogical context, in particular, goals for instruction in writing, followed by what is known of how writing develops and how teaching can best facilitate its growth.

Section II describes technology to date, focusing on the use of the computer as a tool for thinking and composing, communicating, and exploring language.

Section III examines promising areas of research and prototype development. Some of these are natural extensions of the work described in Section II, while others are exciting new possibilities.

Section IV covers the implications of these developments, both the actual and the potential ones for instruction.

Section V details our recommendations.

I. THE PEDAGOGICAL CONTEXT

17. Any consideration of the uses of NIT in education must begin with the question of educational goals. It also needs to include an examination of how students learn and what we know about instruction. In this section we consider these three aspects of the pedagogical context: (A.) the goals of writing instruction, (B.) how writing is learned, and (C.) the teaching of writing.

A. Goals of instruction

18. Written language has always played a dominant role in the school system. Typically, the acquisition of literacy is considered to be one of the most important tasks of the school, for it forms the foundation for all subsequent learning. Writing is an essential component of overall literacy development.

19. It should be recognized that the school is the first and most important writing community in most children's lives. In this community, writing should be defined broadly, to include all forms of composition, from the most basic levels of functional writing to the accomplished use of written language for reflection and learning. It is the school's central task to guide the student to write for different communicative purposes on a wide range of tasks and topics of various degrees of familiarity. One has to recognize that the school may play a greater role in the teaching of writing than in the teaching of reading, or even foreign languages.

20. Writing has several functions, among them, (1) the acquisition and recitation of knowledge (writing to learn), (2) the development of logical thinking, and (3) communication within a social context. In many school systems these objectives are restricted. In some, only communication is emphasized, in others, logical thinking. The recitation function of writing tends to be stressed in all school systems. Differences do exist, however, in whether the aim is to learn content through writing, to integrate knowledge, to repeat given knowledge, or to reveal one's own knowledge by writing. In post-industrial societies citizens require increasingly sophisticated writing skills of all these types.

21. The teaching of writing is also connected with a more general educational goal: socialization through language. To a certain extent this goal has been accepted in all school systems. This leads to either direct transmission of cultural heritage (the "heritage model"), or induction of society's norms and values through linguistic interaction (the "competency model"). In some school systems the development of an an independent, creative mind is also a general objective. This is facilitated by rich

linguistic interactions and a curriculum that concentrates on students, their needs and their emotional and psychological growth. Students express their ideas and emotional needs in writing; teachers provide the materials and guidelines for the students' development.

22. These primary objectives of writing instruction are partially addressed by the New Information Technologies. Section II reviews this technology focusing on tools for writers to use.

B. Learning to write

23. In the past few years we have learned much that provides a solid base for the educational application of new technology. The developing child is viewed, by present-day cognitive scientists, as an active organism in transaction with the environment. This interaction is crucial to the development of intelligence and world knowledge. Investigations of the past two decades, have advanced our understanding of the growing mind of the child. While the causes of changes in developmental status over the life span are not entirely clear, there are some generally accepted principles emerging.

24. First, we know that the roots of formal linguistic expression are embedded in early speech development. Speaking and listening skills are integral to, not just precursors of written literacy. A rich experience in all aspects of linguistic expression is vital to the child's verbal construction of the world.

25. Verbal expression has both cognitive and social roots (cf. Vygotsky, 1978). The very young infant is known to move in synchrony with its human environment. Interactions occur in bursts and pauses and even babies soon learn to take turns. As spoken language develops in the first years of life, the communicative value of language serves to stimulate, and in turn be enhanced by the intellectual and social growth of the child.

26. To support this learning, rich intellectual, linguistic, and social stimulation is necessary, along with the opportunity for the effective exercise of developing skills. Learning by doing is especially important. The toddler learns language best by using it in a warm, supportive, stimulating context. The child also begins to encounter the utility of language in print, and begin to experience the importance of decontextualized representation. Environmental print is incorporated in experience, and the reciprocal processes of writing and reading commence. The maintenance of a social and cognitive environment that supports communicative interactivity is critical at this time.

27. The likelihood of having something he or she wants to communicate increases if the child inhabits an interesting environment. As in the development of early speech, activities in early reading and writing must make sense to the child. The priority of semantics in language must be observed for favorable development.

28. A useful model of writing might mirror recently hypothesized models (e.g., Sternberg, 1985) of the development of intelligent problem-solving, which identify such components as: deciding the nature of the problem to be solved, selecting the problem-solving processes to be employed, deciding on an organization of information, choosing a strategy for combining the processes of components employed, deciding the allocation of attention, monitoring the solution, and maintaining sensitivity to

feedback. Increased experience in both writing and problem solving results in 'automaticity', or enhanced control over the planning, selecting, monitoring, and revising processes, and consequently, in the complexity of the content amenable to such processing.

29. Studies of the writing process have shown that the linear model PREWRITE, WRITE, REWRITE, does not fit reality. The writing process is recursive; there is no straight line from conception to completion. Planning, formulating and revising occur at different stages of text production (e.g., new concepts emerge on the basis of created text). Nevertheless, as long as one remembers that no decomposition should imply rigid stages or a linear model, it is sometimes useful to highlight aspects of the writing process. For the purpose of this report, we distinguish five activities: (a) getting ideas, (b) organizing thoughts, (c) composing, (d) exiting and revising text, and (e) obtaining feedback about one's writing. We also distinguish the specific activities that lead to text production ((a) - (e)) from the encompassing activity of communication with others. Finally, we identify a special category: language exploration activities.

30. The growing child's capacity to express the world in writing provides us with a valuable window on a developing cognitive and linguistic world. Children have impressively complete 'scripts', or event representations at an early age (Cameron, Linton, & Hunt, 1985; Cameron, Linton, Hunt, & Shred, 1985). One task of a writing curriculum is to assist children in making these representations communicable, eligible for contemplation and examination, and the source of further psychological development. The formal representations of written language require the coordination of a host of cognitive skills, strategies, and knowledge, and that coordination is accompanied by the growth of metacognitive awareness, viz., the ability to reflect on one's own knowledge. Budding metacommunicative skills have been documented with preschoolers, but their refinement takes a lifetime of communication experience. The relationship between writing and metalinguistic development is strong. Whether writing promotes metalinguistic development or the reverse may be immaterial to pedagogical practice; the conjunction of these skills is the important point.

31. Skilled writing differs significantly from novice writing, and while learning to write by writing is important, theoretical analyses of the writing process can provide guidelines for an environment that supports the development of writing expertise. Expert models of the writing process that students can emulate are vital. Both teaching and material support in getting and organizing ideas, composing, getting feedback, revising, and publishing appear all to contribute to the development of skill. Most importantly, writing is not a process to be segregated in a language arts curriculum. The content for written expression is as broad as the whole curriculum itself. Students must write in all school subjects, and their writing should be evaluated throughout their school years.

32. To summarize, we know that good writing depends on a rich environment that teaches knowledge of the world and skills to represent and manipulate that world symbolically. Furthermore, we know that development of expertise in writing is enhanced through social interactions at home and at school. Today's technology gives us additional capabilities to put this knowledge to work. It provides new tools for social interaction, enhanced environments for language learning, and methods for teaching in a variety of ways.

C. Teaching writing

33. Teachers of writing today are confronted with many problems. Since the 1960's there has been a rapid expansion of educational systems in many countries: Many students now participate at high levels of schooling. Teachers of all subjects must take into account the needs of these new students; they must adapt traditional curricula to new circumstances and at the same time they must try to maintain standards of achievement. For teachers there is the special problem of transferring literacy skills to growing numbers of students for whom the language of the school and the language of the home differ. Ideally, a substantial portion of the school day should be devoted to writing. Progress depends upon opportunities to write and frequent practice. Individualized instruction is needed, in order to pay attention to the specific needs and competencies of individual students.

34. But, teaching load and teaching time have not kept pace. New subject matter claims part of the teaching hours originally devoted to basic literacy development. Growing pupil numbers and decreasing resources for education only worsen the situation. Within this context the teacher of writing needs help.

35. Quasi-experimental studies have yielded important information on effective teaching strategies (Wesdorp, 1983). Various prewriting activities, i.e., activities focusing student attention on text organization, idea generation, problem-solving categories and rules for systematically treating a subject, have shown to be effective. Among the prewriting activities, the prewriting discussion about the composition assignment is most well-known (and all too often, rigidified), but there are other ways to focus the writer's attention to content and organization aspects. The act of formulating text can also be enhanced by specific instruction. For example, sentence combining exercises appear to have a positive influence on not only sentence structure, but also the general quality of written text. Research has identified peer evaluation as an effective teaching strategy too. The effects of an approach in which students comment upon each other's written texts are predominantly positive. Peer evaluation has a great practical advantage, too: It lightens the extensive evaluation task of the teacher. Positive effects result from revision activities: Rewriting a text after comments by the teacher contributes to the quality of written work.

36. Unfortunately, much of the teaching of writing has yet to be influenced by current research. One problem, alluded to above, is that the amount of time invested in the teaching of writing is small. On average, little more than one hour per week is devoted to writing instruction. This would not be so unfortunate if writing were truly integrated with other aspects of learning. But, when writing is isolated, the scant instructional time means there is little opportunity for feedback, conferences, or revision.

37. There are other factors beyond that of time limitations (Krashen, 1984). Prewriting activities are rarely encouraged; in general, writing is unprepared and triggered by short assignments or essay titles only. Exercises on grammar, punctuation and spelling in isolation still predominate. Generally, only the teacher, and not peers, gives feedback on writing. The feedback that is given is seldom used to revise text: First drafts become final versions. Teaching methods often contain linear procedures for writing; the recursive nature of the writing process is not recognized, much less reinforced.

38. In the light of the above remarks, it will come as no surprise that the intended and the actual

outcomes of writing instruction do not match. In many countries 'functional literacy' constitutes a major goal of education. Yet various assessment studies in a range of countries have shown that many students do not reach a level of writing skill that enables effective participation in society. Long cherished ideals, that students should be able to express themselves in writing, in a variety of situations, audiences and goals, remain beyond reach.

39. It is clear that changes are needed. Writing instruction needs to be intensified. It must adopt a more functional stance and more effective teaching procedures must be employed. Students must be provided with opportunities for writing that are more realistic and challenging. Real audiences and goals should define the assignment. Writing instruction should provide room for planning activities throughout the writing process. Revision should be integrated into writing, preferably avoiding painstaking copying of already produced text.

II. TECHNOLOGY TO DATE

40. In this section we review technologies for addressing problems in the teaching of functional and creative writing. Two trends, in particular, represent important advances over earlier applications of technology to writing instruction. The first trend is recognition of the importance of tools for teachers and students. Tools include, for example, communication networks, aids for planning a written composition, and programs that write other programs.

41. The second trend is awareness that applications of technology require carefully planned computing systems that are integrated into the curriculum, school, and community--not just one or two terminals thrown into a classroom. The development of tools and integrated systems promises to free students and teachers from tedious tasks and to adapt instruction to the varieties of human needs, abilities, and experiences.

42. In parallel with these technological trends, we have learned more about the process of writing. Recent empirical research on writing has revealed much about the nature of expertise in writing, in particular, the way people use top-down and bottom-up thought processes in writing. There had also been substantial research on writing development and on societal differences in the uses and functions of writing. These findings provide a rationale for uses of technology.

43. We first discuss issues in the areas of hardware and general software development. Then we review software aids for writing, including explicit tutorial programs, but focussing on the computer as a tool for writers. This review has three parts, NIT as aids to composition (using the five part categorization outlined in Section I), NIT as environments for communication, and NIT for language exploration. Finally, we discuss evaluation of current software. Because so few substantial evaluations have been done, we describe only three, considering one in detail as a possible paradigm for future work.

A. Hardware and Software Development

44. Educationally relevant technology today includes much more than computers. A broad range of computing hardware, software, and courseware is available, but we also have new storage devices, such as video disks and compact disk memories (CD-ROM), and new means of delivering information, such as cable television and videotex information services. Furthermore, the data base resources needed to make use of new delivery methods, such as on-line dictionaries, thesauruses, and encyclopedias, are reasonably well developed. In addition, many networks allow communication within and across national boundaries--some of these are accessible to the general public. Hence, technology to date includes a broad range of communication devices and resources. The term telematique, perhaps better than any other, represents this wide range of technologies. Plans to apply technology should consider all these resources.

45. Computers themselves are being used by students in a wider range of educational activities than ever before, including tutoring, testing and diagnosis, exploratory learning, communication, and games. Today, students can use technology to learn from direct instruction, from examples, from entertainment, from advisory systems, and from browsing. Teachers have available many administrative and record-keeping aids. Hence, today's technology makes it possible to address the needs of writing teachers, students, administrators, testers, and researchers, and to satisfy the requirements of most educational philosophies.

Hardware

46. Developments in optical character reading, speech recognition, and speech production have broadened the range of senses for communication via technology. One no longer need type at a keyboard to activate a computer; speech is enough. In addition, the tedious typing of text into a computer can be simplified with the aid of optical character readers that not only read what is written, but speak what they read. The sense of touch, for those with limited vision, can be used more efficiently when assisted by computer. Furthermore, touch-sensitive screens can be used to simplify data entry. These new technologies promise applications for very young children, the handicapped, and for computer-naive users.

47. We see few relevant limitations in hardware technology. Reductions in costs and increases in functions continue to outstrip predictions. Since 1970, memory densities have quadrupled about every four years. Processor technologies have developed at the same rate. It is estimated that within ten years it will cost about $100 for a small machine with the computing power of 100 MIPS (million instructions per second), a million characters of random access memory, and four million characters of program memory. This is the equivalent of today's large and expensive computing machines.

48. Output technologies have also improved greatly, including various color systems and dot-matrix and laser printers. These new output devices have been especially important for non-alphabetic languages, such as Japanese. They come in various price ranges, many affordable for home or school use. Video disks are also in use and not too expensive, although they are expensive to develop. One commercial video disk system allows multi-user access to over 6,500,000 records in the United States

Library of Congress shelf list. Compact disk technology is just coming into wide use. It is possible to store, on one CD-ROM (compact disk/read-only memory) disk about the same information as contained in 275,000 typed pages. Such a disk weighs about 150 grams and costs only a few dollars to produce. Currently available CD-ROM disks contain such information as multi-media encyclopedias, the complete 1984 Olympic statistics, and, on one demonstration disk, 8800 public domain computer programs.

49. Input technologies include optical character readers, in wide use for the blind, which read aloud the text that is given to them; however, this technology is expensive. Graphics tablets are inexpensive devices that can be used effectively with children. Voice recognition can now be done reliably by restricting vocabularies and by training the computer to recognize individual voice characteristics.

50. How soon these new technologies will be affordable by most school systems is still difficult to say. A complete system with software and input/output devices may be beyond the reach of many for the next five years.

Software

51. Progress also continues to be made in development of general software (such as course authoring systems) and in the development of specific applications. Search techniques are improving; some computer systems search 30,000 words a second. However, courseware development, i.e., specific instructional packages, continues to be an expensive bottleneck. It takes about 1000 hours of labor to develop an hour of instruction. (This is one of the reasons that recent work has shown a shift towards using the computer as a learning tool, rather than as a tutor.)

52. Thousands of educational software programs exist, and they have improved steadily over the years. But quality is still a problem; educational software must be selected cautiously. Although significant advances in industry have occurred in the development of software tools and methods, the fruits of these development tools have yet to be felt in the educational marketplace. Still, new technology for quality software development can be used to educational advantage. More resources should be devoted to producing high-quality transportable software and developing shared methods of software testing and evaluation.

53. Technology is also unevenly developed throughout the world. One cannot help notice the insularity of nations developing new technologies. Technologically advanced countries should establish methods of sharing effective software with other countries, through demonstrations, international interest groups, and joint ventures that transfer technology to other cultures. Exemplary hardware and software should be adapted for international use.

54. Regulation and coordination of new technologies are major international concerns. Internationalization of an operating system, for instance, demands that it be adapted to differences in local customs (dates, abbreviations, decimal delimiters, and so on). International differences in character representation create problems for table lookup, and linguistic differences, such as whether a language is read from right to left or from left to right, create problems for text scanning and filtering commands. In addition, system interfaces must use words and allow responses in the user's own

language. Finally, paper documentation must be translated. Because of these problems, international standards are necessary.

55. Without standardization, gains by one educational group are unavailable to others. Support should be given to open system architectures, in which information can flow, without hardware or software incompatibilities, across different computer systems. With such sharing, educational advances in one part of the globe can be transmitted instantaneously around the world. Most important, for the future of international hardware and software, is the creation of products with modular components that can be easily changed to adapt to the character representations and languages of different countries. International groups can work together to build such architectures.

56. The world's literature, and data bases of other kinds, such as scores on tests of writing performance, need to be transferred from print to electronic form. Support should be given for converting this information in ways that facilitate later use. For instance, the Oxford English Dictionary is being transferred to compact disk, thus making available tremendous lexicographic information in a computer readable form at a low cost. But there is too simple a coding of the information. Sophisticated linguistic and semantic searches of the dictionary will be awkward without better support facilities.

57. In the next three sections we review software aids for writing, mentioning hardware, network, and other facilities where appropriate. Our intention is to give some flavor of the range of applications that software provides, with the understanding that the usefulness of a particular resource can only be determined in the context of a specific classroom. The emphasis here is on new technologies as tools for composition, communication, and language exploration, for it is the tool capacity that has proven most useful in current applications. In Section III we look at other uses of NIT.

B. Software Aids for Composition

58. The review here is organized in terms of a simple outline of important factors in writing: (a) getting ideas, (b) organizing thoughts, (c) composing, (d) editing and revising text, and (e) obtaining feedback about one's writing. We must emphasize that this organization is in no way intended to imply a linear writing process. "Getting ideas", for example, is an activity that continues throughout the process, and may be triggered by feedback from others or even one's own re-reading of a text.

(1) Getting Ideas

59. Expert writers spend most of their time thinking up ideas and organizing thoughts. The act of putting those thoughts on paper hardly reflects the intellectual struggles that have gone before. Activities in which one invents things to write about can be especially difficult for young children or for those whose knowledge of a topic is weak.

60. Several software programs have been designed to help with the tasks of planning and generating ideas (see also Pea & Kurland, 1986). Those mentioned below are inexpensive and designed to run on common home computers. One program, called CAC, offers children advice about composing persuasive text. The premise is that young children can write better if high-level cognitive decisions

are prompted by the computer. The child can request computer help using a special key. This creates a menu of items from which the child can choose. For instance, advice might be sought about choosing the next sentence. The computer suggests actions based on keywords it finds in the preceding text written by the student. A program called WANDAH (Writing-Aid AND Author's Helper) has a subprogram that turns off the screen, when text is being entered, so that the student is not distracted by the visual image of what is written. (This technique is called "invisible writing.") Invisible writing is intended to keep students from editing text prematurely, which can interfere with the flow of ideas. WANDAH is now offered commercially as the HBJ Writer (Harcourt Brace Jovanovich).

61. Burns, in the United States, developed programs to guide college writers in inventing topics for persuasive, journalistic, and exploratory writing. (Invent) is a suite of programs based on Aristotle's 28 enthymeme topics (Topoi), Burke's rhetorical pentad Burke, and Young, Becker, and Pike's tagmemic matrix (Tagi). The objective of the programs is to stimulate writing appropriate to different genres, based on research in rhetoric and language instruction.

62. Idea generation activities are included in many other programs such as: Quill (D.C. Heath), an extensive program including activities of organizing, composing, and revising text; Prewrite (Boynton/Cook) (for high school students); SEEN (H. Schwartz), a literature-oriented program for high school and college students; Writer's Helper (Conduit), which includes 11 different programs (one, called TREE, displays the tree of ideas developed by the writer), integrated with revision programs (grades 6 to college); Writing Workshop (Milliken), which includes 3 prewriting programs (grades 3-8); and several other special purpose programs, such as Writing a Narrative (MECC), which is a tutorial on narrative structure and point of view (grades 7-9).

63. Activity disks for prewriting also exist. Some are reminiscent of teacher's activity plans, but they offer more student guidance and greater flexibility. These include: Complete Writer (Learnco), which creates three writing environments enabling students to take on different writing roles (grades 6-12); Writing Activities and Language Skill Builders (Scholastic), which offers many different prewriting activities (grades 6-8); and Writing Skills Bank (Scholastic), which also offers prewriting activities, but for the lower grades (grades 4-6). These activity programs all require the Bank Street Writer (Broderbund) word processing program.

64. Dozens of interactive stories and story makers are available that might be included under the rubric "getting ideas," because they stimulate writing partly by providing context. These include Adventure Writer (Codewriter), which allows creation of dialog-style adventures (high school), and Interactive Toolkit (Interlearn), which allows creation of interactive stories.

65. Data bases of information should be included within prewriting resources, since they make it possible for students to browse text as a method of stimulating their writing. These would include dictionaries (for instance, the Oxford English Dictionary, now being put on compact disk), and the host of information facilities available from videotex services, such as those offered on Prestel. There are also many microcomputer-based data bases, such as Australia's Bushrangers (KnowWare), which allow students to explore new worlds of information.

66. One might also include adult data base management programs, for instance, PFS: File (Software

Publishing), ZyIndex (Zylab), or Fulcrum (Fulcrum Technologies), in the storehouse of software that might aid writing through literature access. However, these are not integrated in a way that a student could easily have access to all the resources immediately at one terminal. Integrated systems require more sophisticated computing resources than early home terminals provided. Research systems, such as the ZOG data base system from Carnegie-Mellon University, and the Hypertext Editing System (Hes) and File Retrieval and Editing SyStem (Fress), from Brown University, suggest useful directions for today's small but powerful desktop computers.

(2) Organizing Thoughts

67. Organizing one's thoughts is a second important activity of writing. The computer offers the capability of moving text around in various ways and of viewing it from different vantage points. For instance, some outline generating programs, such as Framework (Ashton-Tate), create empty, numbered outline structures within a word processing program. Programs like NLS expand and collapse outlines. Using NLS, a writer develops an outline by adding levels to a hierarchical structure with headings such as 1, 1a, 1a1, and so on. Lower levels of information in the outline can be hidden from higher levels; thus, the writer can move about at different levels of text. Related programs include ThinkTank (Living Videotex), MaxThink (MaxThink), and Freestyle (Summa Technologies). These programs have such intellectual potential that they have become known as "idea processors." Prices for such programs range from less than $100 up to $700.

68. Another technique for organizing thoughts is to use notecards. Several programs intend to help with the notecard function, including Executive Filer (Paperback Software International), Thor (Fastware), and Notecards (Xerox PARC). Notecards includes a multi-windowed display that allows a writer to create individual notes that can be linked to other notes. Notes can contain graphic images or text, and a writer can browse through notes using icons.

69. One program, included in the Unix Writer's Workbench (AT&T Bell Laboratories), strips away all text except headings and the beginning and end of paragraphs, giving the author an uncluttered view of text transitions. Similar features in Writer's Assistant (Interlearn) allow the user to see only the first sentence of each paragraph, or to flip between a sentence by sentence format and the conventional paragraph organization.

(3) Composing

70. Technological aids that support the composing process include programs that help expand ideas in a text, which might exist in only outline form. Previously mentioned programs, such as the hypertext editing system from Brown University, can be much more than outline programs. Electronic hypertext documents are networks of related ideas that can be gathered to expand what one is writing. For instance, a person reading an article about cars has a choice of how much detail to see about the history of cars, their manufacture, their relation to the rubber industry, and so on. Movement through this connected text can be controlled by mouse, rather than keyboard. Hypertext still requires large computers, but its principles are reflected in programs such as Xerox's Notecards.

71. Many other programs exist whose function it is to build poetry or other text. These include

general purpose computer languages such as logo which can be used to create random poetry, to poetry generator such as Marcus's Compupoem (University of California, Santa Barbara) or Levin's Poetry Prompter (Interlearn).

72. Rubin's (1980) Storymaker program (BBN Laboratories) allows students to create and manipulate text units larger than the sentence. Story structures are represented as a tree consisting of nodes connected by branches. The nodes contain sentences or paragraphs. The student first creates a story by chosing branches to follow; the program adds its text segments to the story as the child chooses.

73. Any literary data base could be grist for students' composing. It is accepted practice, in the teaching of composition, to have students use the writing of famous authors as models for their own writing. Not only style, but content can be copied. Parts of a student's own compositions might be copied to build new text. Access to the world's literature would be a fine resource for copying. In this way, society would transmit its ideas and images to individuals. There are over 350 vendors of on-line and time-sharing search services worldwide, with data bases in virtually every academic domain. There are over 600 major electronic data bases. Many useful literary data bases, however, are in private hands or located in universities and college around the world.

(4) Editing and Revising Text

74. There are hundreds of word processing programs that allow children and adults to enter and revise text. Some, like Bank Street Writer, present menus of functions from which the author chooses, thus making it easy to learn and to use the system, but with some sacrifice of flexibility. There is some evidence that young writers function most effortlessly with more powerful word processors (Cameron, 1985; Levin, Boruta, & Vasconcellos, 1982). Many authors, especially adults and professional writers, want to control details of text format, and they need footnote and indexing functions. Nota Bene (Dragonfly Software), is a powerful program aimed at academics and sophisticated writers. The program has been endorsed by the Modern Language Association. It is a word processor, but it also permits access to indexed notes and has capabilities for tables of contents, lists, footnotes and endnotes, bibliographies, and indexes.

75. Several commercial keyboarding programs have been created to help children and adults learn typing skills. However, the need for explicit instruction may not be necessary during the early school years (Bruce & Rubin, 1984a; Cameron, et.al., 1985).

(5) Obtaining Feedback about Writing

76. Research has shown that computer programs, created to assist students with the revision process, improve student editing skills. For instance, Writer's Workbench includes over 40 programs that provide feedback on spelling, diction, style, and other text characteristics. An interactive version of the program works within a text editor; it suggests correct spellings for words, and will automatically replace them if the author desires. A writing laboratory has now been designed based on trials of the system by the English Department of Colorado State University. Smaller programs, which do some functions of the Writer's Workbench system, are also available. The Writer's Assistant, developed for young children (by Levin, Boruta, & Vasconcellos, 1982), checks spelling and other features, and

allows students to try out various sentence combinations. IBM's Epistle system, under development, has a parser that detects complex linguistic problems, such as subject-verb agreement. Thesauruses, such as the Random House Electronic Thesaurus, provide word alternatives that stimulate student text revision; hence, students learn from them even though programs are advisory rather than tutorial.

77. Feedback about many other features of writing could be given. For instance, with little effort records of progressive drafts of a paper can be kept and used to provide writers with a trace of changes made in the process of writing. Document tracking systems exist today, but mainly in research and development laboratories.

C. NIT as Environments for Communication with Others

78. The importance of social interaction argues against the use of computers as isolated machines. It is through social interaction that human qualities develop, and social interaction is an important component of writing. It is by feedback from others, by whatever means, that writing skills develop. Peer tutoring has been shown to promote writing development. Several writing programs, such as the Quill Mailbag and Library facilities, allow writers to share their products (Bruce & Rubin, 1984b). The Computer Chronicles News Network (CCNN) allows children to share news items from around the world. Current work with the Intercultural Learning Network (Cohen & Miyake, 1986) is exploring the use of electronic messaging for learning.

79. A variety of computer conferencing systems exist that might influence writing at adult levels. They include the Swedish National Defense Research Institute network (COM), which is a worldwide electronic mailbox, Turoff's Electronic Information Exchange System (EIES), and various networks, such as ARPANET, BITNET, EARN, USENET, CSNET, MAILNET, and JANET. These and other research systems have developed the technology for conferencing systems, such as NOTEPAD, eForum, and CONFER. A system developed at MIT, Newspeek, creates personal newspapers. Readers use keywords to describe their interests, and news stories from wire services are filtered according to each reader's list of keywords. Newspapers can thus be produced, which are tailored to each individual.

80. One important element in the popularity of computer text processing systems is the ability to format text to achieve communicative goals. Technology can provide students with the ability to publish their own newsletters, papers, or books. Desktop publishing, at modest cost, is here. For instance, the MacPublisher software, which allows various formats and integration of text and graphics, costs about $150. Publishing compositions can be intrinsically motivating for students.

81. Other programs create communication environments modeled upon those used widely in the adult world. Newsdesk (Cambridge Language Arts Software) is a computer-managed simulation game in which the players take on the roles of newspaper sub-editors. The computer acts as a teleprinter giving news updates, and also offers screen-editing facilities. EDFAX (Tecmedia Ltd.) is a "Teletext (Videotex in the U.S.). Emulator" - a micro based version of an information display and retrieval system such a Prestel. It allows users to store, edit and display pages or text and graphics. It is particularly useful for creating an electronic newspaper or bulletin board.

D. NIT as Tools for Language Exploration

82. Students learn most from activities, such as games, that are meaningful to them and promote active involvement (especially when abilities are challenged, but success is attainable). Programs such as Gram (Sharples), Interactive Toolkit (Levin, 1982), and Iliad (BBN Laboratories), allow students to explore language by playing with its syntax and semantics. Interactive Toolkit, for instance, contains a high-level language that redefines what the computer can do. Using it, a writer can create programs with new functions, for example, to provide templates to guide letter writing.

83. A host of language games are commercially available. For instance: Crossword Magic (Mindscape), allows teachers or students to create crossword puzzles. The activity encourages exploration of word meanings and relationships, as well as spelling. Developing Tray (Acornsoft) is a game based on the close procedure. Readers adopt predictive strategies in order to uncover a text in which all but the punctuation marks have been left out. Adventurer (Chelsea College, London) is a suite of programs which allow users to create their own text-based adventure games. Talkback (Acornsoft) is a version of Eliza in which the user can create his/her own bank of match-words and responses. It allows the user to make on computer "personality" have a conversation with another.

84. Sharples (1980, 1985), developed several programs, including Gram, which generates text using rewrite rules. Another program, Tran, allows students to write their own transformations using pattern action rules. Children learn characteristics of grammar through such programs, but more importantly, they develop a sense of the rule governed aspect of language in general and develop their own ability to create and solve problems. Application of the programs to everyday composition needs to be explored.

E. Evaluation

85. Very little of the existing software for teaching writing has undergone a formal evaluation. There are several reasons for this: Software changes rapidly so that new versions appear in less time than one could carry out an evaluation of the existing version. Publishers, and even governmental research agencies, are often interested more in the next product than in analyses of existing software. Adequate evaluations are difficult, time-consuming, and expensive. Many schools still do not have sufficient hardware for the necessary in situ studies. And, perhaps most importantly, new technology is never more than one component in a complex system that includes interalia teachers, teacher training, existing curricula, school schedules and procedures, testing, and maintenance of equipment (Michaels, 1985, 1986; Michaels, Cazden, & Bruce, 1985).

86. Nevertheless, there are promising initial studies. One example is the evaluation of Quill (D.C. Heath), which was carried out in 1982-3 (Bruce & Rubin, 1984a). It is presented here in some detail, both as an example study, and, because Quill represents a composite of features present in many other systems, i.e., the Quill evaluation can, with some qualification, be taken as representative of an evaluation of an approach to the use of NIT in the teaching of writing, not just that of a particular piece of software.

(1) Quill

88. Quill (D.C. Heath) is a set of microcomputer-based writing tools and writing environments. The software can be used for writing on any subject in grades 2-12. Integrating reading and writing skills, Quill encourages students to create written products through planning, drafting, revising, and sharing.

89. There are four components of the Quill software: Planner helps a writer generate and organize ideas before writing begins. Library is an information storage system that allows students to produce texts for other students to see, index them according to keywords, and retrieve them as one would information in an encyclopedia. Mailbag is an electronic message system that encourages students to communicate via computer with the teacher, with other members of the class, or with students in other classrooms. Writer's Assistant (Levin, 1982) is an editing system that is accessible whenever students enter or revise text.

90. The Quill Teacher's Guide explains how to use the software and suggests activities that integrate Quill with instruction in language arts, science, social science and math. It also contains the COOKBOOK, a series of lessons for introducing Quill and the writing process to a classroom. In addition, a detailed plan for training teachers to use Quill has been developed and field tested.

Quill and the Writing Process

91. Quill activities encompass the planning, composing, revising and publishing aspects of the writing process. Prewriting activities include the use of Planner to help children generate and organize ideas for composition. A teacher, for example, might hold a brainstorming session with her class to list categories relevant to a topic (e.g., reviews of popular games) and record the results in a Planner which students could use in developing their ideas for texts.

92. Reading, writing and spoken language are integrated throughout the prewriting stage. A child might create an interview form using Planner in order to conduct research on a topic. When the child is ready to plan a composition, Planner is used to formulate main ideas and details, structural organization, and point of view. Children are encouraged to work in small groups or pairs as they conduct their research and plan their compositions.

93. Students can compose and revise their drafts using a text editor, Writer's Assistant, which enables students to delete, add to, or rearrange their text easily. Children find revision more enjoyable and less tedious when the amount of recopying is reduced.

94. Quill provides two types of communication environments, Library and Mailbag. Library is an environment in which children store their writing using the complete title of the piece (rather than a six letter file name), their full name, or names, if they work in pairs, and keywords, which tell what their writing is about. Students can create encyclopedias of expository prose as well as collections of narratives or poetry. Mailbag is an environment in which children send electronic mail to others. It helps children realize the communicative function of written language. Messages can be sent in letter or memo form and can be addressed to pen-pals, to the teacher, to friends with secret code-names, to special interest groups, or to an electronic "bulletin board."

95. Revising, like planning and composing, can also be a process of sharing. The Quill Teacher's Guide suggests ways to use drafts and Planners as tools in writing conferences. Library and Mailbag encourage students to comment on one another's writing, so that revisions can be made that respond to audience reaction. Children can use a printer to produce copies of their texts to give to peers, teachers and parents. Having final copy that looks good and is correctly formatted encourages students to publish their work so others can read it.

Field Test Results

96. A field test of the Quill system was conducted in Massachusetts (a rural site), Connecticut (an inner-city site), and New Jersey (a suburban site) during the 1982 academic year. Students in the five field test classrooms ranged from third through fifth grade. Pretest and posttest writing samples of Quill classes and matched control classes were scored using a primary trait scoring system. This system measures the effectiveness of writing in terms of the primary goal or trait of the writing assignment. Though the quality of all the students' writing improved in the course of the year, the writing of students using Quill improved significantly more than that of students in the control classes in both expository and persuasive genres. Details of this field test can be found in Bruce and Rubin (1984a). A summary follows.

97. On an expository writing pretest in October of 1982, Quill students scored an average of 1.96 (on a scale of 1 to 4), whereas students in control groups scored an average of 2.05. In May 1983, the same students took an expository writing posttest. Quill students scored 2.60 while control students scored 2.21. For each grade level (3, 4, and 5) Quill students achieved statistically significant gains as well as gains above the conventional standard of .33 standard deviation units. In contrast, two of the control groups did not demonstrate either statistically significant or benchmark (.33 S.D.) gains.

98. Similar results were obtained for persuasive writing. Quill students progressed from 1.97 to 2.69 on the 1 to 4 scale. Control students on the other hand, progressed from 1.72 to 2.09.

99. A second analysis of the data demonstrated that for both persuasive and expository tests, the differences between posttest scores of Quill and control students groups were statistically significant in every case, while only one of the cases (3rd grade, expository) showed a significant difference on the pretest (i.e., the Quill and control groups differed at the end, but not in the beginning of the study). Moreover, for four of the six cases the differences on the posttest were greater than the .33 standard deviation benchmark.

100. Students in grades 3-5 who used Quill improved their ability to write well in two specific genres: exposition and persuasion. These genres are characteristically the types of writing required of students in post-elementary grades, as well as in post-secondary education. Improved ability in these areas addresses one of the most critical need areas in education. Teachers, administrators, and parents of students using Quill all described marked changes in student attitudes towards writing, and improvement in specific skills and general writing ability. Quill students wrote more often, both in school and at home. Teachers observed students successfully applying rules of punctuation and capitalization while at the computer. Teachers reported a greater tendency in students to revise their

work.

101. Additionally, Quill students learned to use software tools modeled after real world applications. Familiarity with such tools contributes to computer literacy, perhaps more effectively than simple programming does.

102. The field test results indicate that the effects of Quill are educationally important. Quill has helped students to understand the purpose of an assignment, and to communicate their ideas effectively. Other evaluations of Quill have shown improvement in students' expressive writing as well (using a primary trait scoring method). In one study Quill students' posttest writing samples were almost twice as long as their pretest samples.

103. Quill was approved for dissemination by the U.S. Department of Education for grades three through five, but has been used with students of all ability levels in grades one through twelve. It is now in use in approximately 2000 classrooms.

Limitations

104. There are, however, many unanswered questions. Results such as those described here reflect only one facet of learning to write. Many of the most intriguing effects could not be measured in such a design. For example, in some cases, revision occurred not just because the text editor facilitated the mechanical act of editing, but because Quill catalyzed changes in the social organization of writing, e.g., more collaboration (Bruce, Michaels, & Watson-Gegeo, 1985). Moreover, in many school systems it would have been difficult to implement Quill as successfully as it was in the field test sites. Recent research is beginning to unravel some of these complexities.

105. One observation has been confirmed several times: The teacher makes the major difference between success and failure, whatever the success criterion used (Michaels, 1985, 1986, in press; Michaels, Cazden, & Bruce, 1985; Rubin & Bruce, 1986). The construct of a writing system, which embodies the norms, beliefs, and values surrounding the act of writing, is now being used to emphasize that NIT are at most one piece of a large puzzle. Learning, in general, is a complex social act, and writing, in particular, must be viewed as the communicative, social act it is if we are to understand how to bring about change.

(2) Writer's Assistant

106. Writer's Assistant (Interlearn), the text editor in Quill, was also evaluated independently. Again, this evaluation is limited, but it can be taken as one piece of data on how the use of text editors might effect writing.

107. Levin, Boruta, and Vasconcellos (1982) worked with two classrooms, one using Writer's Assistant and one not. Students generated pre-computer-use and post-use samples of writing using pencil and paper. In the experimental (Writer's Assistant) class, there was a 64% increase in writing sample length versus 4% in the control class. On a four-point holistic scale, using blind ratings, the experimental group's scores increased from 2.00 to 3.09 after the 4-month period of use of the text

editor. The control group decreased slightly, from 2.27 to 2.24.

108. As in the case of the Quill evaluation; we believe these results should be viewed as tentative, but worth further exploration. We need to know how, when, and why the use of NIT aid growth in writing.

(3) Writer's Workbench

109. The Quill and Writer's Assistant evaluations were done with children; a similar study was done at the university level at Colorado State University, using Writer's Workbench (AT&T Bell Laboratories) (Frase, Kiefer, Smith, & Fox, in press). The results in this study did not reveal statistically significant differences in writing gains between the control and experimental groups, because all the students showed significant gains in writing. There were however, several other positive findings. Students who used the computer were reported to have a more positive attitude about writing: they progressed more rapidly; and they averaged one more revision on each paper. Teachers found grading and responding to papers easier because of uniform formatting and typing. Perhaps most importantly, students began to look at their writing in a new way, asking questions they never asked before. Frase, et al. suggests that these indirect consequences of using computer may be as important as the direct effects.

III. PROMISING AREAS OF RESEARCH AND PROTOTYPE DEVELOPMENT

110. In this section we discuss basic research to clarify issues we must understand in order to use New Information Technologies effectively. This discussion is organized around six major categories of impact of NIT on the teaching of writing: (A.) NIT as tools for composition (most of the software examples in Section II fall into this category), (B.) NIT to create environments for communication, (C.) NIT to enable language exploration, (D.) NIT as writing tutors, (E.) NIT to improve our understanding of the writing process, and (F.) the need to redefine writing and writing instruction because of NIT.

A. New Tools for Composition

111. One approach to the problem of using New Information Technologies for the teaching of writing is to de-emphasize the teaching component and instead provide computer-based tools that can assist the writing process. Toolkits are becoming commonplace in the business and academic world, and the task is to adapt and develop them for more general use. The maxim is: Beginners Need Powerful Systems. Learners have just as wide a range of problems to solve as experts, but they are less skillful at presenting their needs clearly and unambiguously. Consequently, the computer system should not only offer powerful problem solving and writing aids; it should also be helpful, able to deal with errors such as spelling mistakes, and capable of explaining its actions.

112. When computer toolkits are used to aid writing, they function both as facilitators of writing and

as devices to enhance the learning of writing. We have identified several characteristics of such a toolkit, which builds on current technology (Section II.B), and could lead to immediately useful computer-based writing tools.

A Composition Assistant

113. There has been a spate of projects in recent years on computer systems to assist writers in the production of conventional articles and books, or to create 'electronic media' such as databases, text file systems, and on-line encyclopedias. Many such projects were discussed in Section II (also see Meyrowitz & van Dam, 1982; or Yankelovich, Meyrowitz, and van Dam, 1985 for useful overviews). Although powerful systems already exist in some forms, the research in this area is still in an early stage.

114. This work is leading toward a general purpose Composition Assistant, which would offer help throughout the writing task. It would allow writers to work at the idea level, sorting ideas into categories and then arranging them into a pictorial 'concept map'. This map would then serve as a guide to the writer, who could specify further constraints, of style and layout, to the system. The system would then monitor the text as it was being typed, to ensure the constraints were satisfied. It might perform many of the functions of a proofreader, correcting spelling, tidying headings, references and quotations into a consistent format, and indicating repetitions.

115. The system would also offer a writer the opportunity to specify the presentation of the document, either by giving layout directions or by directly manipulating chunks of text on the screen. It would also have a stock of pre-defined layout formats - headings, column widths, typefaces etc - for particular applications.

116. Because writers often need to collaborate, the Composition Assistant would include aids for commenting on another's text. As with Notecards (Xerox), authors could make marginal notes, give reasons for changes, ask questions, and suggest alternatives. There would also be multiple representations of the same text: as a network of paragraphs, as a set of headings, as a collection of ideas linked to actual text passages, and so on.

117. It is important to consider not only the quality of the authoring tools, but also how these tools relate to one another. At one extreme there might be a number of applications packages, one each for creating text, diagrams, tables, etc. and the final document would be pieced together from the product of each package. At the other extreme is a fully-integrated system. As the author moves to a diagram within the document, picture editing functions would be available, moving to a table would activate table-editing functions, and so forth. New techniques of 'object-oriented programming', in which each element (a sentence, a table, a diagram) is an active object with its own rules of style and presentation, offer the best means of designing such an integrated environment.

Aids for Special Needs

118. We have identified several categories of special need for computer-based writing tools: adult illiteracy; hearing impairment; survival writing. Some programs have already been written primarily

for the disabled. The Iliad program is aimed at deaf children, as is a suite of programs from Hull University (Ward, Sewell, Rostron, & Phillips, 1983). The term 'survival writing' is used to describe those types of writing needed to get by in a literate society: filling in tax forms, applications, and surveys; writing job applications and reports etc. If the content of the document is sufficiently circumscribed then a program might offer advice not only on grammar and style but also content. Such 'expert systems' are already under development, for example to assist with welfare benefit claims and tax forms; they could be extended to other areas of expertise. Expert systems are, however, costly to develop, requiring detailed analysis of users' skills and knowledge.

119. Major research issues concerning the computer as a tool for composition include the following:

analysis of how such tools can best be integrated with other classroom activities.

exploration of developmental trends in the use of such tools.

assessment of the social, cognitive, and communicative consequences of the use of such tools.

B. New Environments for Communication

120. Thus far, we have assumed that readers and writers of the 'electronic media' are in close proximity, but that need not be the case. Electronic mail systems already span the world and the links between sections of an electronic books could be similarly stretched. Systems are now under development that allow multi-media messaging and conferencing, i.e., users have the capability to send not just text, but images, graphics, spread sheets, voice and ultimately video (e.g., the Diamond system at BBN Laboratories (Thomas, Forsdick, Crowley, Robertson, Schaaf, Tomlinson, & Travers, 1985). We know little today of the full possibilities of such systems for enhancing communication.

121. International co-authorship and readership brings both possibilities and problems, the problems arising from differences in technology, language, and culture.

122. A priority for the future is to ensure compatibility between electronic mail systems, so that mail transactions can be made as swiftly and efficiently as telephone calls. As for the language barrier, machine translation systems are already in daily use, for example in translating documents produced for the E.E.C. They are not particularly effective and require a human to tidy up the grammar of the resulting text, but they may be sufficient for international electronic mail. Simpler aids, such as on-line multilingual dictionaries would also help communication across borders.

123. The greatest barriers, those of culture and race, can only be overcome by regular, useful, communication between people. An exciting development is the 'electronic newspaper'. This has no publisher, printer, nor editor. Contributors send in items under specific headings by electronic mail to a central computer which automatically collates them and distributes to subscribing machines. Such 'Newsnets' could be extended to link and inform people with common interests, regardless of nationality.

124. Even among the community of researchers and teachers who have been interested in NIT and writing, the importance of communication environments has been underestimated. Much of the work to date has been on text production (our Section III A.). Research is needed to explore how NIT can enhance sharing of those texts with real audiences.

C. New Ways to Explore Language

125. Students can also use the New Information Technologies to discover aspects of the language itself. What is needed is a language exploration package, that would allow a learner to discover the patterns and processes of writing, to improve her idea gathering and planning abilities, and to extend her repertoire of writing styles and techniques.

126. Recent research (Flower & Hayes, 1981; Gregg & Steinberg, 1980; Scardamalia, 1981) stresses writing as a cognitive process, open to conscious inspection and control. A general awareness of thought and language is necessary, but not sufficient. The child, or adult, also needs to understand the particular processes of writing, the patterns and forms of language and the relationship between writer and reader. From the research perspective, there is still much to be learned about these patterns and forms.

127. The Logo programming language (Feurzeig & Papert, 1969; Feurzeig, Papert, Bloom, Grant, & Solomon, 1969) and 'turtle geometry' (using Logo to command a 'turtle' - a small motorized cart - to draw shapes) has been successful, with appropriate environmental support, in enabling children to explore shape, space and direction and to learn the skills of modelling and problem solving. We need an equivalent 'turtle geometry for language', that could help children to understand the forms and processes of writing. Over the past decade computer programs have been written to reproduce many aspects of language production and comprehension - generative grammars, parsers, translation systems, information retrieval systems - and some of these are now being adapted for use by learners. They offer an environment for creating generative grammars, looking at patterns in language, exploring the bounds of meaning and syntax and understanding the process of idea creation and planning.

128. Some of the language exploration programs, such as the Interactive Toolkit (Levin, 1982) and Iliad (Bates, Beinashowitz, Ingria, & Wilson, 1981) are complete packages. Others are extensions of Logo. Phrasebooks and Boxes (Sharples, 1985) are two additions to Logo that that allow children to classify words, create their own dictionaries and phrasebooks, devise a quiz, write a program that will converse in natural language or build their own 'Adventure Games'.

129. Language exploration software is still rudimentary, lacking adequate documentation, project material, and the presentation necessary for general distribution, but is a promising area of development.

130. Language exploration need not be confined to exercises designed to shape well-understood skills. For instance, a common practice in language instruction is to have students copy the writing styles of expert writers. With tools that now exist, some feedback could be given to students, by computer, on features of experts' writing that are missing from their writing. Such activities could be

the basis for group interaction and problem solving in the classroom.

131. Important research issues concerning language exploration include the following:

analysis of priority skills that might be targets for language exploration tools.

analysis of how language exploration, on computer, can be integrated into classroom activities.

development of algorithms for educational activities so that they can be incorporated into new educational software.

D. New Ways to Tutor Writing

132. One part of learning to write is the accumulation of formal skills - procedures for spelling, punctuation, style, organization and presentation. Some of the current writing software is designed to teach these skills explicitly, but the programs are severely limited by a lack of knowledge about writing and the writer. Recent research in Artificial Intelligence and Intelligent Tutoring Systems has addressed such issues. 1332. The first requirement of an Intelligent Tutoring System for any task is that it should have some ability to perform, or at least, discuss articulately, the task in hand. This demands explicit knowledge of the task. Thus, a spelling tutor should be able to correct misspellings and to identify them as instances of general spelling rules. Two other important requirements are a representation of the student's current knowledge, so that opportunities can be seized to teach in the most appropriate way and to diagnose misconceptions, and a knowledge of ways of teaching.

133. Providing an Intelligent Tutoring System for rule-governed aspects of writing is a difficult problem. Not surprisingly, little of the software reviewed in Section II fits in the ITS category. Nevertheless, the problem appears tractable in principle. One such program is Iliad (Bates, et al., 1981) which was designed to tutor deaf children who have difficulties in mastering language forms such as negation and question forming. It contains a sentence generator which is capable of syntactic variations of a core sentence. For example, from the sentence "John ate the apple"; Iliad might generate: Did John eat the apple? What did John eat? Who ate the apple? etc The tutoring component asks the child to carry out similar transformations and comments on the result.

134. Iliad could be extended to allow children to design their own transformation rules, either using a simple grammar notation, or by using example. Thus a child might propose: Which apple did John eat? as a new transformation of 'John ate the apple' and then test it on other sentences. The child might type 'Mary sees the cat' and the system would use the rule to produce 'Which cat did Mary see?'.

135. The act of writing demands far more than the following of grammatical rules, yet programs that can comment on literary style, plot development or emotional impact are not likely to be developed in the near future. Even if they were produced, we might well not wish to use them. Every human author and critic draws on cultural and aesthetic assumptions that others might find objectionable. Literary critics have not been able to find objective criteria by which to assess text, so we cannot hope to incorporate such criteria in an automated teaching system. An important research issue thus emerges:

How can Intelligent Tutoring Systems, which have shown such promise in other domains, such as mathematics and science, be applied in teaching aspects of writing? Or, does the act of writing differ fundamentally from these other areas?

136. It is by no means clear that tutorial systems are appropriate for all students. Many adults prefer to learn on their own, and they have the skills to acquire and use scattered resources such as might be found, for instance, in a general data base. In addition, the cost of developing tutorial instruction is high. Finally, there are many things we don't understand about subject matter. Hence, we see three important research issues concerning tutoring systems:

description of the student populations for which tutorial instruction is most effective.

analysis of the costs and benefits of tutorial and other forms of computer instruction.

description of the subject matter domains for which tutorial instruction is most suitable.

E. Using NIT to Improve Our Understanding of the Writing Process

137. New information technologies can assist the teaching of writing or the exploration of language, as well as the act of writing. Each of these functions merit serious consideration from researchers, practitioners, and policy makers. But there is a fourth function, which may have an equally significant impact. That is, NIT can be used as a window into the writing process itself, thereby revealing the thinking and learning that occur in the act of writing.

138. Despite extensive research on writing in recent years (Frederiksen & Dominic, 1981; Graves, 1981; Hillocks, 1986; Whiteman, 1981), we still know too little about how writers generate ideas, how they revise, how they use what they have read in writing, or how their writing changes over time. One reason is that many such processes take place in the writer's head, and even external manifestations, such as pauses, backtracking, use of resources, oral interactions with others, and so on are difficult to record or quantify.

139. With text being produced and stored on the computer, there arise new possibilities for examining the writing process. Some text editors already offer a 'replay' facility which re-enacts an entire editing session, allowing student and teacher to see the process of text creation. The Writer's Workbench described above, not only gives assistance with writing, it also offers detailed analysis of any text that gives a rich picture of the writer's use of language. Pain (1985, Thesis Edinburgh University) not only corrects spelling errors, but also gives a profile of the types of error: phonetic, letter transposition, etc. Another possibility is to design a program that detects linguistic features, such as word repetition, ambiguity, inversion or ellipsis, and makes its analysis available in such a way that the writer's thinking processes are partially unveiled.

140. Research issues have to do with discovering new features of subject matter that can become the focus for technological assistance. These involve developing profiles of types of writing that students do, and creative methods for providing feedback about that writing, during the writing process, as

well as at the final product stage.

F. A Redefinition of Writing and Writing Instruction

141. NIT are rapidly becoming essential fixtures for writing outside of schools as well as in school. Many people now use text editors, formatters, and computer message systems. The advent of multi-media messaging, low-cost random-access mass storage devices, "idea processors", hypertext, and other such devices will change writing further. We need to ask, not only are NIT appropriate for teaching writing, but is the very of NIT presence in the adult writer's world a cause for rethinking the writing curriculum?

142. Ten years from today, will we say someone is accomplished in his writing skills if he cannot use a word processor? Will such a person be able to engage in writing in the workplace if he cannot read and write electronic mail? Will the boundaries between thinking, reading, writing, and even programming become fuzzy as more and more powerful computers are used for a greater variety of problem solving tasks (see Bruce, in press)? Such questions are difficult to answer today, but they deserve consideration. Research is needed to redefine what we will be forced to mean when we discuss literacy in the future.

New Forms of Text

143. Increasingly, computer-based writing is never published as words on a printed page. Electronic mail, on-line documentation, and 'electronic encyclopedias' are read directly from a video screen. The computer is a new communications medium and we have only just begun to discover its possibilities. Computers are well-suited to creating 'connectivity': webs of related information. Explicit connections, or links, allowing readers to travel from one document to another (as one does with an encyclopedia) or from one place within a document to another, can be made with little effort by an author. The computer can help a reader to follow trails of cross-reference without losing the original context. Electronic document systems also facilitate co-authoring of text. A group of children, for example, can create a common electronic notebook, by creating their own contributions, viewing and editing one another's items, then linking the items together.

144. Ideally, authors and readers should be given the same set of integrated tools to create, browse and develop text. They would be able to move through material created by other people, add their own links and annotations, and merge the material with their own writings. In consequence, the boundaries between author and reader could largely disappear. Research is needed to understand these changes and the consequences they have for writing instruction.

IV. IMPLICATIONS FOR INSTRUCTIONAL PRACTICE

145. We are still at the beginning of the two major educational changes mentioned in the Introduction section, namely the revolution in the use of NIT in education and the revolution in the teaching of

writing. If present trends continue we will see dramatically different classrooms in the next generation (Bruce, in press). But detailing these changes is not an easy task.

146. Evident already are bad, as well as good, effects of the two revolutions, e.g., inequities in access and use of NIT are widespread (Michaels, Cazden, & Bruce, 1985). There are also contradictions apparent in the current trends: NIT seem to foster simultaneously more controlled and more open instructional practices. The same program may be used in different settings to achieve diametrically opposed objectives. As if mixed outcomes and contradictory applications were not enough to confound the futurist, there is another source of uncertainty that must be considered: Researchers, teachers, administrators, software developers, publishers, and policy makers are active agents in these changes. What we all do today will influence tremendously what happens. (We hesitate to say "determine" because these changes are also affected by forces well outside the educational realm.)

147. We consider here a few of the implications these changes have for instructional practice, focusing on those areas in which appropriate actions today can make a significant difference on future educational outcomes.

A. Tools for Composition

148. New Information Technologies facilitate almost every aspect of the writing process (see Sections II.B and III. A). Because they make writing easier, they can help in motivating students or in assisting the teacher to focus where help is needed most.

149. Using word processors, students are able to produce text that can be read more easily. The printed format can provide confidence for students. It also means that the text can be read by a variety of readers and that handwriting does not influence the grading of content and structure. The text editing function allows corrections to be made easily without decreasing the readability of the text. Students with reading and writing disabilities can also produce texts easier that before. The computer can check spelling and even wording.

150. These functions are already changing the way writing is done outside of school. They can also produce changes in both writing and writing instruction within the school.

151. The possibilities for exploiting New Information Technologies as tools for composition depend to a large extent on the teaching strategy. If pupils only write compositions on assigned topics and instruction is based on the teacher's corrections and notes, a word processing program is beneficial only with regard to surface features; such as grammatical correctness or spelling. If, on the other hand, teaching emphasizes the writing process and includes, e.g., brainstorming, planning, searching for data, and revising the text, as well as feedback from the teacher and classmates, NIT provide possibilities for quite different kinds of work.

B. Environments for Communication

152. NIT are changing writing in a second major way, as well. New environments for communication are now appearing. We will still write for the conventional manuscript and publication forms, but we

will also be writing electronic mail and creating hypertexts. These new forms of writing are already entering the school context; preliminary findings are that they can facilitate learning to write (Bruce & Rubin, 1984a) and learning other subjects through writing (Cohen & Miyake, 1986). It is important today to look at how new communication environments impact school writing.

C. Language as a World to Explore

153. In various areas of science and mathematics, computer-based microworlds have been developed. These allow students to explore new domains, testing out hypotheses, constructing models, and discovering new phenomena. NIT can also be used to create analogous microworlds for language. Investigations of such microworlds can be highly motivating for students, but just as importantly, they cause students to think seriously about concepts such as language patterns, conceptual relationships, and the structure of ideas. We are at only the beginning of this potentially powerful mode of using NIT for language instruction.

D. Intelligent Tutoring Systems

154. Similarly, intelligent tutoring systems have until now been applied primarily in areas of science and mathematics. As computers become more powerful, as storage of large amounts of text becomes more feasible, and as we learn more about how to use NIT for teaching, we should see greater use of intelligent tutoring systems in writing. Systems that embody expert models of the writing process, for example, have been proposed. Also, we should soon see systems that integrate tutoring functions with computer tools and communication environments.

E. Understanding the Writing Process

155. Over the last 20 years, work on artificial intelligence (AI), including the development of systems capable of common sense reasoning and the use of natural language, has had a major impact on studies of thinking and learning in people. The shift in perspective brought about by AI approaches has been more significant than the specific programs that have been produced. In the area of writing, for example, work in AI and related cognitive science areas has led to a deeper understanding of the essential planning processes in composition.

156. Computer systems have thus served as models for the human activity of writing. They also serve as laboratory tools in the sense that they help make previously invisible processes visible. When a writer uses computer tools for generating ideas, organizing thoughts, composing, editing, or obtaining feedback, a trace can be generated that is henceforth available for inspection by the writer, a teacher, or a peer. The trace can reveal problems in writing or help to improve strategic (metacognitive) processes. The revelation function of NIT is just beginning to be understood and utilized. Together with the modeling function growing from AI related work, it has the potential to improve greatly our understanding of the writing process.

F. New Conceptions of Writing and Writing Instruction

157. The use of new technologies not only affects teaching methods, but also content and objectives.

The extensive adoption of word processing and other new technologies will change written communication, the writing process, and the handling of documents. Writing instruction should take these changes into account, including the question of how instruction can prepare students to cope effectively with the demands of the information society.

158. The use of computers should promote the attainment of the general goals of school education. Writing instruction is especially critical here because it is often through writing that the student develops a world concept as he or she combines information obtained from different texts, from experience and from discussions.

159. In general, there is too little time in school for discussion, argumentation, and development of the students' thoughts and conceptions. In the current practice of the teaching of writing, attention is often focused only on practicing the skill itself and not on the actual meanings that are conveyed in the writing. Similarly, in the teaching of other subjects, attention is frequently focused only on the correctness of the students' answer. In order to avoid this, we need integration across. Writing instruction, utilizing NIT, such as computer data bases, intercultural networks, hypertexts, and so on, could act as an integrative factor between subject areas. It would help to focus students', attention on the content and purpose of their writing by facilitating access to texts and communication with responsive audiences.

G. Applying New Information Technologies

160. Research in the area of gender differences in learning shows that, in general, girls excel at verbal tasks, and boys, at spatial problem-solving, and now, in using computers. There is some evidence that learning to write with a computer (Cameron, 1985; Linn, 1984; Michaels, Cazden, & Bruce, 1984), might attenuate these traditional differences, that is, girls who use a word processing program become more motivated to write when they can use a computer to do so.

161. This is but one example of the way the use of NIT may have an impact far beyond simple improvement of learning in a given subject area. Other research has noted greater collaboration with other students and improved motivation, especially for the disaffected learner (Bruce, Michaels, & Watson-Gegeo, 1985; Rubin & Bruce, 1986).

162. It is fair to say, though, at this point, that we simply do not yet know the full effects of applying NIT in the teaching of writing. We do know that attention must be paid to the context of application, e.g., to teacher training, follow-up, on-going support, maintenance of equipment, administrative policies, testing, integration with existing curricula, language differences, scheduling, and many other factors that influence successful use (Loucks-Horsley & Hergert, 1985; Michaels, 1985a, 1985b, in press; Michaels, Cazden, & Bruce, 1985; Rubin & Bruce, 1986).

V. RECOMMENDATIONS

163. Many of the recommendations of the Working Group on Writing pertain to the use of New Information Technologies in education in general. These are covered in the overall introduction. Here, we detail those recommendations that apply specifically to the use of NIT for writing instruction. Because we are still in the early stages of this work, several of our recommendations call for further research on the applications of NIT.

164. In the area of writing, the best documented, most effective current use of NIT is as tools for composition, specifically, tools for getting ideas, organizing thoughts, composing, editing and revising text, and obtaining feedback about one's writing. A second use, of growing importance, is the establishment through NIT of new communication environments (e.g., electronic mail systems). Uses of NIT as to create microworlds for language exploration or intelligent tutoring systems for writing are just beginning to be developed, but hold great promise for the future.

165. The pedagogically effective development of NIT for the uses just outlined requires three types of research. One type is research on the writing process itself, with and without the aid of NIT. We must build upon what we know of the cognitive and social factors involved in composition. In this way, the design of NIT for writing instruction benefits from basic writing research. At the same time, NIT provide us a window into the process by making writing events visible and analyzable.

166. The second type of research needed is on the design of better technological systems for use in writing instruction. The level of technology available today for business, industrial, medical, scientific, and military applications far exceeds what is available to schools, even in the most advanced OECD countries. Some of this disparity results from short-term cost considerations alone, but much can be attributed to inadequate visions of whether and how to use NIT for teaching. Research is needed on developing cost-effective NIT applications suited to the educational setting. We need exemplary prototypes that can be studied and adapted for use in new settings, and tools for instructional designers to use in developing new programs.

167. Third, we need research that brings together studies of the acquisition of writing per se with research and development of NIT for instruction in writing. Specifically, we need a better understanding of how NIT can be introduced into classrooms or laboratory settings, how teachers should be trained, what sorts of support are needed to achieve success, how the social organization of the classroom changes, how computer expertise in students develops, and what are the negative effects of introducing new technologies.

168. In addition to research and development of improved methods of teaching writing based on NIT, we need better means of communicating what is being learned. There should be expanded use of electronic networks for exchange of research reports and computer programs, and for collective problem solving. Such networking should also be extended to student use, for the possibilities of enhancing writing through the use of such systems seem immense. There should also be demonstration and evaluation centers at which software and other technologies can be compared,

where results from different countries can be evaluated, and where long-term development efforts can take place with the collaboration of researchers, software designers, and teachers from different countries. International centers of this sort would also facilitate exchange among countries with very different experiences and levels of development in the use of NIT in writing instruction.

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