COMPUTERS AND WRITING

Gavriel Salomon, Ely Kozminsky, & Merav Asaf

ABSTRACT

The technological environment, in which writing takes place, affects both writing and cognition. However, this depends on the design of the technological tools that support writing and their use. The chapter reviews writing with technological tools, specifically writing with word processors and related tools. We argue that the reported mixed effects of using computer tools in students’ writing, should be analyzed according to the long lasting “effect off” vs. the direct “effect with” technology usage paradigm, coupled with the types of students’ literacy activities and the context of their learning environment. The direct “effect with” word processors tend towards more easy production but less planning and less meaningful revisions. Instructionally guiding tools, such as Computerized Supported Intentional Learning Environment (CSILE) and Writing Partner, that provide scaffolding and stimulate writing-related cognitions, improve self-regulation and metacognitive monitoring of the writing activities. Collaborative-based writing tools, synchronous and asynchronous, embedded in meaningful learning environments
provide another dimension of knowledge construction. In these environments, writing becomes an important mediation channel together with additional supporting “mindtools”, such as outliners. These mindtools can produce not just sequential essays but hypertexts that provide additional means of constructing and presenting knowledge.

**Keywords:** Word Processing, Writing (composition), Writing Skills, Computer Uses in Education, Knowledge Construction, Collaborative Learning, Cognitive Processes
INTRODUCTION

COMPUTERS AND WRITING

All forms of writing require some kind of material technology. First, writing requires what Bolter (1991) has defined as a “writing space”, that is “the physical and visual field defined by a particular technology of writing” (p. 11). Second, writing requires implements that enable the process of writing – the wedges used to inscribe clay tables by the Sumerians, the quill, the plume, the pen or the keyboard. And third, writing requires craftsmanship, a “teche” (Ellul, 1964) without which the technology-as-material and tools would be useless.

Importantly, technologies designed to extend human communication and knowledge construction capacities affect the role that craftsmanship has to play. As technologies change, nowadays entailing capacities that mimic, even exceed, human ones, so does the required craftsmanship. New technologies deskill older craftsmanship replacing it with a new one. Copying by hand the Holy Scriptures must have required a very different craftsmanship than writing with a ball pen. And as professional writers often testify (Snyder, 1994), writing with a word processor is a profoundly different process requiring yet another kind of craftsmanship and possibly different ways of conceiving of writing and reading a text (Haas, 1996). Does this technology-determined change of craftsmanship leave any lasting cognitive footprints on a child’s mind?

Writing not only serves to turn (preexisting) private thoughts into a permanent public record, thereby extending memory (Donald, 1991), but it also shapes the writer’s thoughts and ideas: “Our graphic systems not only preserve information but also provide models, which allow us to see our language, our world, and our minds in a new way”
(Olson, 1994, p. 258). But whereas this may be the general case, one would need to ask whether and how the technology of writing affects children’s writing in any profound and unique way. Does the way writing is carried out – by chiseling signs into stone, by inscribing on wax, or by writing on paper - differentially determine the generation of ideas, the quality, structure or fluency of the written product? Does the technology of writing matter in terms of the immediate cognitions involved in writing? Moreover, does the shift from one to another technology of writing (particularly the shift to computer-based writing and communication) affect the writer’s more lasting and transferable writing-related capabilities?

Such questions are not new. They have been raised in the past by scholars such as McLuhan (1972), and Ong (1982). Although writing is both a cultural practice as well as an individual’s cognitive activity, the question of how writing with different technologies affects the mind has been addressed at mainly the cultural level. Thus, McLuhan (1972) argued that print has laid the foundations for the assembly line, for mass production, and for cause-and-effect thinking; Ong (1982) argued that “Without writing the literate mind would not and could not think the way it does...Writing has transformed human consciousness” (p. 78). Concerning writing in particular, Bagert-Drowns (1993) has postulated that “The computer as a tool, as a spread sheet, data base, networking link, graphic generator, calculator, and word processor is transforming the way the “information age” society lives and works” (p. 70). Bolter (1991) speculated that print-based writing “expects the humanities, including metaphysics and ethics, to be relatively stable and hierarchically organized” (p. 234). Hypertext, he argued, has very different expectations. We will return to this argument later on.
While such large-scale effects may indeed take place on a cultural level, we are concerned here more with the minds of individual children. Olson (1977) tried to bridge the gap between the cultural and the individual level, pointing both to the differences between oral and literate cultures and between pre-literate and literate children. What about the role of technology, particularly as children become initiated into a technology-based culture of literacy? Would writing and communicating with computers affect their processes and products of writing, and their acquisition of writing-related capabilities any differently from the way print-based writing may have affected them? Haas (1996), based on a Vygotskian notion of socio-culture mediation, argued that technology does matter, significantly affecting individual’s writing and cognitions. We do not espouse technological determinism; we are fully aware that the way one chooses to use technology plays no lesser a role than that played by the technology. Clearly, technology, the person using it and the culture within which it is been used play reciprocal roles in affecting each other. While being cognizant of this reciprocity, we nevertheless wish to deal here with the question of technology’s effects on children’s writing.

**Different kinds of “effect”, different usages of technology**

Not all effects are born equal. Thus, we need to introduce a distinction between effects “with” a technology and effects “of” it (Salomon, Perkins, & Globerson, 1991). Effects “with” a technology pertain to changes in cognitions or performance, such as more intensive employment of metacognitions or a lengthier phase of essay planning, improved spelling, or more paragraph revisions. Such changes take place *while* a
student is writing with a particular word processor, or with the help provided by in-process prompts (e.g., Reynolds & Bonk, 1996). However, effects of this kind, although often desirable, are not necessarily maintained over time and writing occasions when writing is done with another technology. These are effects that are contingent upon the presence of the technology that enables them and occur only during its use. On the other hand, effects “of” a technology pertain to more lasting and generalizable changes of writing-related cognitions, strategies, abilities and dispositions that are the consequence of writing with, say, a prompting word processor. These become manifest when writing takes place in the absence of the technology that brought about these changes.

We need to keep this distinction in mind when we ask how and under what conditions does this or that technology affect writing processes, products and capabilities. Effects with, say, a word processor on cognitions activated during essay planning are not necessarily the same as those more durable and generalizable essay planning dispositions and abilities developed as a consequence of using that tool. Indeed, being able to engage in more meaningful revision when probed by a program such as Reynolds and Bonk’s (1996) Generative-Evaluative Computerized Prompting tool, does not mean that the students have become better at revising their essays or more disposed to engage in revision in the absence of that tool. Improved performance (effects with a tool) is not the same as improved ability or mastery (effects of a tool’s usage).

But effects of what? Computers are neither a uniform technology nor are literacy-related activities with computers uniform. In fact, there is a continuum of tools and
usages along which research and development attempts can be arranged. This
continuum ranges from the simplistic to the more elaborate, and from the stripped down,
non-instructional tool, to whole encompassing instructional settings (Bangert-Drowns &
Kozma, 1989).

Specifically, on one side of the continuum we have the employment of word
processors for essay writing, the effects of which were often studied in the early years of
computer use. On the other side of the continuum we have the design of whole new
learning environments, most often based on constructivist and social-cooperative
principles (e.g., Lamon, et. al., 1996). In between the two poles we have semi-intelligent
guidance and prompt-providing writing tools as well as guided idea organizers and
outlining tools. These, usually stand-alone tools, are not necessarily part of a whole new
kind of learning environment. However, unlike typical word processors they often entail a
partner-like quality, guiding the writer to think about the essay’s readers and provide
prompts for revision (e.g., Bonk & Reynolds, 1992). In other cases, the prompts during
planning, production, and revision serve as externalized metacognitive-like guides that
are contingent upon the writer’s inputs (Zellermayer, Salomon, Globerson, & Givon,

In light of the variety of tools and usages as illustrated above, it appears that the
question of whether, how and to what extent does the computer technology for writing
affect the processes, products and capabilities of writing in general or of planning in
particular is unanswerable in its general form. Any generalization pertaining to the
influence of “The Computer” on children’s planning and writing (as distinguished from
the possible influence on a whole generation or culture) would be unwarranted. As is so
often the conclusion arrived at in educational research and in particular in what concerns the effects of word processors on children’s writing, the answer is “It all depends” (Cochran-Smith, 1991). And “it” depends on what particular tools and instructional arrangements are the source of the alleged effect, what is being affected, how it is affected, and what kinds of literacy activities the students become engaged in while working with the technology. In the next sections we briefly review the field according to the continuum of tools mentioned earlier.

**Word processors**

The common assumption pertaining to the use of word processors was that the opportunities afforded by the tool for planning, writing, but mainly essay revising, will change writing processes, products and abilities. One of the first fully developed studies was that of Diaute (1985) whose findings did not support the expectation that word processing will affect planning and writing in any meaningful way. The findings of other researchers, employing only word processors without particular instruction, were consistent with Diaute’s (see review by Dahl & Farnan, 1996). For example, Hass (1989, 1996) carried out one of the few studies on the effects of word processors on essay planning and found that it resulted in less planning than writing by hand. She also found that planning pertained less to global and conceptual aspects of the essays and more to technical and sequential ones. Thus, her elementary school age writers tended not to have a sense of the whole text. It is possible that, given the known attraction of word processors, they “lure” the children to turn more quickly to the production of essays, while forgoing planning. Still, Bangert-Drowns (1993) report that the overall quality of the
essays produced with word processors tends to be of somewhat higher quality. But the effects found are marginal. Were the evaluators of the essays impressed by the essays’ length or by their clean and errorless drafts? Or is it possible that due to mechanical ease, planning becomes more distributed throughout the writing process when writing with word processors? Research so far does not provide clear answers to such questions.

Several researchers reported that word processors enable and promote collaborative writing, resulting in higher quality essays and in the writers’ greater awareness of the writing process (Bruce, Michaels and Watson-Gegeoo, 1985; Crook, 1994; Davies, 1989; Dickinson, 1986; Snyder, 1994). However, this slightly increased awareness does not seem to manifest itself in essay revision. Revision of essays written with word processors, unlike those written by hand, seem to be more distributed throughout the writing process (Owston, Murphy, & Wideman, 1992). However, again, when using word processors, students do not appear to have a ‘sense of the whole text’ (Haas, 1989, 1996), thus revising more mechanical elements (such as correcting errors up to the sentence level), than conducting global revisions (e.g., Bridwell-Bowels, Johnson, & Brehe, 1987). This can be due to the difficulty of reading on-line (e.g, Gould & Grischkowsky, 1984), the limited information viewed on the computer screen (Haas, 1996), or due to the lack of global planning.

In all, results of the research on writing with word processors yielded weak and often mixed results and has been critically summarized by Cochran-Smith (1991) and by Peacock and Beard (1997). The latter concluded as follows:

[M]any of the supposed benefits of word processing have not been confirmed by
research evidence. In addition, many devotees fall victim to simplistic technological determinism ... and enthusiastic qualitative accounts frequently ignore considerable teacher assistance when reporting improvements attributed to word processing (p. 289).

**Instructionally-guiding tools**

The theoretical rationale underlying the question of whether word processors affect children's writing is, as we have seen, pretty slim. Why, indeed, should word processing, in of itself, have any profound effects on writing, save a few shallow, mechanical effects? The empirical evidence tends to generally bear this out in its weak and mixed results. The picture changes when instruction is added to the computer-based activity. There are two kinds of instruction that should be mentioned here. One kind of instruction is independent of any computer affordance or activity but may be accompanied by the latter, as when students are didactically taught about different writing genres and are then sent to the word processor to write an essay in one of the genres (e.g. Nuvoli, 2000).

The second kind, and of much greater relevance here, consists of instruction, tutorship, or guidance which is built into a computer tool in a way that capitalizes on the computer's capabilities and affordances, on the one hand, and evokes, scaffolds, guides or overtly simulates writing-related cognitions, on the other. One such early tool was designed by Woodruff, Bereiter & Scardamalia (1981-1982) in which “14-years-old students composed for the first time opinion essays on a computer, using an interactive program that led them after each sentence through a branching sequence of questions designed to induce means-end planning of the next sentence” (described in Bereiter and
Another tool of that kind was designed by Diaute (1985), incorporating such on-line prompts as “Can your reader see, hear or feel what you have described?”. Most prompting programs that developed later on followed these early examples. They often provided prompts that addressed writers’ planning, writing and revising metacognitions, expecting not only to attain effects with the programs during prompted writing, but also more lasting effects of it, as when students learn to prompt themselves on their own, thus acquiring an ability for self-prompting.

The strong emphasis on prompting and on modeling writing-related metacognitions is justified on the grounds that, as Bereiter and Scardamalia (1987) have pointed out, since the process of writing lacks the guidance, feedback and prompting of face to face conversation, it becomes an unsupported, unguided autonomous process. Older and better developed writers rely quite heavily on their self-regulatory capabilities, continuously conversing with themselves in lieu of the absent partner. However, younger writers experience great difficulty in self-regulating their planning and idea production since live conversation entailing continuous inputs does not require these (Bereiter & Scardamalia, 1987). That is, live conversation does not prepare the child for the kind of self-regulations that writing requires. Thus, prompting elementary school children’s memories during writing (“What else do you know about this?”), or prompting them to provide explanations and elaborations appear to facilitate the number of discourse elements they use in their essays quite significantly. The provision of metacognitive-like prompts is supposed to serve in both a compensatory function of procedural facilitation for the not-yet developed self-regulation as well as a model for such to be emulated. Whereas the former would facilitate writing while the prompts are provided, the latter
would become manifested in the form of improved self-regulation.

The designs and studies by Bonk and Reynolds (1992) and Reynolds and Bonk (1996) serve as good examples of this genre of computer-based writing tools. Bonk and Reynolds (1992) designed a word processor to provide upon request generative and evaluative prompts (e.g., “Ask yourself: What other ideas does this suggest?”; “Think about the problem or original topic. Is everything you’ve said needed or related to it?”). Participants, sixth, seventh and eighth grade students, were required to request the prompts a particular number of times during three writing sessions.

The findings of this study failed to support the researchers’ expectations. Perhaps most importantly, the incident of meaningful changes in writing that coincided with the prompts constituted only 14% of all changes, suggesting that many of the prompts the students were exposed to were not acted upon. Overall, although the prompted students engaged in somewhat less surface revisions, they did not engage in any more meaningful revisions, relative to non-prompted students. This was particularly pronounced for the younger (sixth grade) students who seemed to benefit somewhat more from the generative rather than from the evaluative prompts. This led the researchers to consider the possibility that students of this younger age may not yet be capable of benefiting from externally-provided writing-specific prompts for they may not yet know how to act upon them. Revision, as also found out by others (e.g., Bereiter & Scardamalia, 1987) turns out to be particularly difficult for younger students.

A number of factors may account for these results. One such factor, also identified by Zellermayer et. al., (1991), may well be the difficulty or reluctance poor writers have in reading the sometimes lengthy prompts. Another, more profound factor
concerns the absence of any relationship between the text being produced and the
prompts accessed. The provided prompts are supposed to model metacognitive activity.
But action-specific, real-life metacognitions, whether regulating writing or reading,
planning or revising, are by their very nature highly contingent on the ongoing activity.
One would hope that, capitalizing on the computer’s affordances, its provided prompts
would be textually and structurally contingent upon one’s actual writing. They were not.
Also, the effects studied in the prompting studies mentioned so far concerned effects
with the technology, attained while prompting took place. Effects of prompting,
manifested in more lasting, transferable improvements in specific writing-related self-
regulation, were not seriously investigated in these studies. Does computer-generated,
contingent prompting improve writing ability (not just performance) through an increased
tendency to engage in self-regulation?

The study by Zellermayer, Salomon, Globerson, and Givon (1991) addressed the
latter two issues – contingency of the prompts on the young writers’ inputs, and their
effects on the writers’ tendency to become self-regulating in the absence of the
prompting tool. That study, employing the computerized Writing Partner, was based on
the assumption that a computer tool can function in a child’s zone of proximal
development (Vygotsky, 1978) by offering an explicit and dynamic model of regulation
that can be “internalized” to serve in a cognitive function as self-regulation. This
assumption was tested in an earlier study with a Reading Partner, that provided ongoing
metacognitive guidance during text reading (Salomon, Globerson, & Guterman, 1989).
Seventh graders reading eleven texts with the Reading Partner showed significantly
better reading comprehension of unguided texts than their peers in the other two groups;
they also showed significant improvements in essay writing quality a while later, suggesting that such a guiding tool can have generalizable effects in the form of a greater disposition to employ reading and writing-related metacognitions for self-regulation.

The Writing Partner tool employed by Zellemayer et. al. (1991) in a subsequent study, was designed to facilitate writers’ move from “knowledge telling” to “knowledge transforming” (Bereiter & Scardamalia, 1987). It strongly emphasized the guidance through the planning phase but also guided the writers through writing and revision of their essays. Middle school children were led to brainstorm their main ideas and assign these ideas to particular categories such as hero, triggering event, conflict, setting, timing, resolution, minor event, and the like. The writers associated their ideas with appropriate icons and keywords. Using this icon-based format of outline-planning, the students could then arrange the icons/ideas in a two dimensional space. All that pre-writing information was kept in the computer’s memory. During writing itself, the computer could “identify” in a semi-intelligent fashion the keywords used in the planning phase and present the writers with content appropriate metacognitive-like questions: e.g., “Does John, your hero, have any feelings? Did you mention them?”; “If this is a conflict, have you got an idea how it will be resolved?”, etc. Students could also request help when they felt difficulties during writing and be guided by the program to self-diagnose their difficulties (e.g., “If you are stuck, how would a movie continue the story?”; “Think of another opening such as …”). Revision entailed similar choices and guides.

Findings were quite clear: Receiving unsolicited prompts lead to the writing of
superior essays with the tool and later on also without it. The unsolicited guides benefited good and poor writers alike. Still, in line with other studies, revision processes were not affected by writing with the guidance of the tool as much as planning processes were.

It thus appears that a computerized tool -- (a) that provides a developmentally appropriate model of writing-specific metacognitions; (b) which offers novel, useful, and learnable cognitive functions particularly geared to the planning phase of writing; and (c) whose guidance is contingent on writers’ inputs, can be emulated and used both as an aid to performance and as a cultivator of more lasting and transferable capabilities (Salomon, 1988).

However, such computer-based procedural facilitation of writing is based on a relatively narrow, albeit traditional, conception of literacy as an isolated, decontextualized activity. As pointed out by Flower (1996), textual literacy as practiced in schools suffers from an exclusive focus on individual performance and from a preoccupation with the manipulation of context-free symbolic information. This agrees well with the claim that students often learn to write while word processing without having any words to process and without having a real audience to write to. The alternative view suggests seeing literacy as a “social practice of making texts, supported by explicit instruction in the problem-solving strategies a writer brings to the rhetorical situation” (Flower, 1996, p. 27). Emphasis thus shifts to what Flower calls “literate action”, which - inspired by a more general conception of cognitions that are situated in the real world and embedded in particular contexts (e.g., Lave & Wenger, 1991) – translates into collaborative, contextualized writing.
The question thus arises as to whether team-based planning, whereby students engage in collaborative essay planning and writing that resembles literate action and facilitates socially distributed cognitions, improves planning quality and following that - writing. Employing the Writing Partner, Elliott and Salomon (1992, unpublished) carried out a study with Australian young female students, considered poor writers. The students planned essays collaboratively or individually and then wrote the essays either in teams or alone. The differences between the two modes of essay planning were striking: Team planning was significantly more elaborate, more thoughtful, took far more time than individual's planning, and had a clear and strong effect on the overall quality of the essays, whether written alone or in teams. Interestingly, although essays written in teams did not differ in their overall quality from those written alone, the students participating in team writing claimed that they preferred to write alone. Apparently, planning is an activity that affords team-work more than text production.

**The design of whole new learning environments**

The improvement in planning and in subsequent quality of collaborative writing suggests that it depends not only on the computerized tool as a stand-alone. The findings suggest that a deeper change may be required, one that is based on the conception of literacy (in fact, intellectual activity and learning in general) as a socially and culturally embedded activity. Such a conception of literacy has many implications. One important implication concerns the idea of writing for a real, personally and socially significant audience; a second implication is that writing is to be done in the service of one's engagement in an authentic problem or issue, rather than as a process designed to
serve itself (e.g., Williams et al, 1998). Cohen and Riel (1989) have found that seventh graders' quality of essays written for distance peers was significantly better than the quality of essays written for their teacher. Similarly, Riel (1990) found that the performance of fourth graders on a standard test of basic skills improved significantly as a function of writing for a peer audience and particularly as a function of editing the essays of peers for a classroom newspaper.

Writing activities involving teams, peer audiences, and problem solving contexts cannot be carried out very well in traditional learning environments. Indeed, researchers and educational designers have in recent years felt a need for a new conceptualization of the contexts of learning in general and writing in particular, and consequently for the redesign of appropriate learning environments. The impetus for such a move came from three closely related sources – the above mentioned criticism of the isolated writer engaged in near-sterile writing exercises, new conceptions of learning, and the availability of computer technology that could help in turning these conceptions into actual classroom practices.

There are two closely interrelated conceptions of learning that underlie and guide the design of novel learning environments. The first conception of learning regards learning as a constructive process, whereby learners do not absorb, acquire, or internalize knowledge but rather construct it in their own way: “Children don't get ideas, they make ideas” (Kafai & Resnick, 1996, p. 1). A number of implications follow from this basic tenet. One such implication is that learning and actual doing - in the form of problem solving, writing or designing a product - are closely interwoven (Perkins, 1992). Thus, for example, one learns to write by having a real problem to solve and write about.
A second implication is that students' activities, the ones that are to lead to learning, need to be goal oriented. Thus writing, for example, is to be carried out within the context of problem solving and as part of that process rather than as an isolated, often content and context-independent activity. Writing becomes a tool in the service of problem solving and designing (Andrade & Perkins, 1998).

The second conception, closely related to the previous one, pertains to the issue of social learning. The origins of this conception go back to the Vygotskian theory that development entails inter-personal processes that can become intra-personal ones within a child's zone of proximal development. It is also based on more recent theoretical developments concerning the socially distributed nature of cognitions (e.g., Resnick, 1991; Cole & Engestrom, 1993), the relationships between individual and social learning (e.g., Salomon & Perkins, 1998), and findings showing the actual learning attainments of student teams (e.g., Slavin, 1994).

These conceptions, when put together, lead to the design of new team-based, exploration- and problem solving-oriented, information rich, and non-didactic learning environments. Student activities, writing in particular, become integrated into the exploratory, communicational, team-based activities, whereby writing is carried out for the purposes of problem solving and communication and for specific real-life audiences. One such environment is the Computer Supported Intentional Learning Environment (CSILE) of Bereiter and Scardamalia (see e.g., Scardamalia, Bereiter, & Lamon, 1994). CSILE is a computer-based environment designed to promote intentional learning of students by providing the guidance and technological means to facilitate knowledge construction. Students carry out in writing discussions about selected issues, problems
and questions they themselves raise ("I wonder why an offspring will resemble one parent and not the other", a question raised by one participant during an ongoing exploratory exchange about heredity). The discussions are a-synchronic whereby a student may enter an idea, hypothesis, a possible explanation, question, insight, and the like, and will place it under one of these categories. Gradually, a communal data-base becomes created, shared by all, driven by students’ curiosity and knowledge, and based on the information they gather from a variety of sources.

Since the discussions are a-synchronic writing is one of the backbones of the process, being the main medium for students’ exchanges of ideas, exploration, argumentation, and questioning. It is thus not surprising that students of varying ages in CSILE classes showed impressive effects with CSILE, particularly with respect to the quality of arguments raised, the extent to which counter examples were discussed, the number of causal explanations provided, the analogies and predictions offered, and the like (e.g. Hakkarainen, Lipponen, & Jaervelae, 2001). Most importantly, though, also clear and strong effects of CSILE were recorded in the area of reading, using standard tests, and in the area of writing. These effects are particularly important to note since no direct instruction in reading or writing was provided.

In another project CSILE was combined with two other projects: Fostering Communities of Learners (Brown & Campione, 1994) and The Adventures of Jasper Woodbury (Cognition and Technology Group at Vanderbilt, 1994) into one project – Schools For Thought (SFT) (Lamon, et. al., 1996). In that project students carried out research and discussions in teams on topics such as planning a trip to Mars. While dealing with such a problem, students had to pull in knowledge from a variety of
disciplines and communicate through CSILE among themselves and with experts outside the classroom. Teams became experts in their respective sub-topics and then became reorganized in a jigsaw manner. Writing was one of the major media of communication, but to no lesser an extent also a tool with which each team could gradually construct its own products.

As is typical of this genre of novel, constructivist learning environments, writing was not a focus of instruction in SFT classes. Students’ readings served their writing, and their writings served their needs to communicate to share knowledge, to try out new ideas, to critique, and to argue. But since good, clear, comprehensible written communication was very much the norm, it should come as no surprise that writing quality showed impressive improvements. Thus, for example, the reports written within the “Mission to Mars” and the “Endangered Species” projects by the sixth graders were “better than almost anything we have seen from sixth-grade classrooms...Students wrote more, organized better, used better and more complex sentence structure, and improved in punctuation, capitalization, and usage. Knowledge and their ability to express it were impressive” (Lamon, et. al., 1996, p. 262).

As for effects of the project, the writing ability of SFT and control group students was assessed based on essays students wrote. Students were asked to write an essay about "If you could change something about your world, what would you change? Why? How?". Analyses showed that SFT students scored significantly higher on overall quality than control students in the same schools -- controlling for prior differences in students’ language ability. SFT students also scored higher on eight of ten categories including structural aspects of introduction, transitions, and conclusion; content aspects of
argument and coherence, and mechanical aspects of spelling and vocabulary. When divided into high, medium, and low scorers (based on the standard achievement test scores), SFT students outscored control students at each level (Secules, et. al., 1996).

However, not always do such improvements show up on standard achievement tests of language mechanics such as punctuation, grammar and vocabulary. This was also the results of some CSILE evaluations. There is a clear discrepancy between the researchers’, parents’ and teachers’ observations, on the one hand, and the students’ performance on standard achievement tests, on the other. One explanation is that the latter does not tap the kind of writing that is emphasized and practiced in the SFT classrooms. Writing in the SFT classrooms emphasizes research, collaborative planning and composition for real purposes, for real audiences and for idea-constructive and communicational purposes. Typical state-mandated standard achievement tests often do not focus on these. Quite clearly, an evaluation of the quality of writing in SFT classes, as in other novel technology-intensive constructivist learning environments, needs to take into consideration the new approaches to literacy that emphasize literate practices that are embedded in a mindful, purposeful and social context (Flower, 1996). New measures need to be devised to tap development of children’s literacy along these lines.

Studies of the kind just described have one major drawback. In the novel constructivist learning environments, with their highly integrated social, curricular, instructional and technological components, it is impossible to determine the extent to which the technology, in and of itself, leads to any specific literacy improvements (Salomon, 1991). Thus, if one asks how much does computer technology really matter,
meaning how strong are its “net” effects, other things held constant, it would be impossible to provide an answer. While it is true that the computer, when properly used, is essential in realizing the educational conceptions underlying the new class of learning environments, it is quite impossible to single out its unique effects. Paradoxically, to be truly effective, one needs to design novel learning environments that emphasize team-writing within a context of, and in the service of, meaningful problems to be solved. However, the very systemic approach to the orchestration of such learning environments makes it quite impossible to determine the exact contribution of technology to the improvement in writing or in learning. Authenticity overrides certitude; considerations of effective instruction take precedent over scientific-analytic rigor.

**Lessons to be learned**

The conclusion stated above still leaves open the question we have started out with: What non-trivial difference does technology make in the process of writing and in the process of acquiring writing-related skills? Many of the studies designed to answer this question, particularly the ones carried out with word processors, arrived at weak or mixed results. Other studies with stronger effects are the ones that “confounded” the technology with instruction or embedded it in a complexly integrated learning environment. In this light, one would be tempted to respond to our initial question by arguing that technology, in and of itself, does not really matter that much for children’s writing; instruction does (Clark, 1983).

Let us carry out a hypothetical experiment by examining a more extreme case. We could ask whether such a conclusion would still hold when the technology shifts
more dramatically from writings in the typical linear manner, having a beginning, a middle and end, to a vastly different kind of writing: hypertext. Hypertexts involve textual nodes and links among them, yielding a web, rather than a continuous text. Although each node may entail “regular” text, it is the absence of any predetermined organization of the nodes that makes hypertexts so unique. Hypertext “texts” allow movement from one node to another in a great variety of directions in endless combinations, and without necessarily having any preset order. Movement within a network of such links, typical of multimedia programs, would fit well a constructivist conception of learning whereby students literally construct their own texts while exploring a topic (Cunningham, Duffy & Knuth, 1993).

What implications follow from here for writing in hypertext style? According to Bolter (1991), hypertext-like writing will lead to the abandonment of the ideal of uniform, high culture, with its standardization and unification, leading to a (postmodern) network of diverse and non-hierarchical cultures. If all combinations of hypertext are legitimate so are all points of view, perspectives and interpretations. To this one could add that hypertext writing is not guided by a desire to attain logical coherence and continuity along a story line or an argument. Rather, hypertext is guided by a desire to link together in a more logical or more associative manner a loose collection of diverse textual items. Writers do not have to envision a single structure for their writing products nor a single kind of audience; different audiences could construct the text each for its own purpose and each in its own way.

Hypertexts are profoundly different from regular texts and this difference warrants the expectation that hypertext writing is likely to affect the process, the qualitative nature
and the competencies of writing. Indeed, initial reports suggest that the way students go about writing hypertexts is very different from the way they usually write regular essays (Lehrer, Erickson, & Connell, 1994). It is because of this rather profound qualitative difference between the forms of writing distinguishing regular texts from hypertext, that in this case, unlike that of word processors, writing is likely to change significantly. Contrary to the hype associated with them, word processors did not call for a kind of writing that was qualitatively different from what writing by hand called for. The texts were still linear, they still had to have a beginning, middle and end, they still were supposed to have coherence and continuity, and they still had to be addressed to a particular audience. On the other hand, hypertext appears to change the very nature of the text to be produced and thus the very nature of the process of writing, and, of course, its outcomes. Whether it will affect writing capabilities remains to be seen.

There is a possible lesson here. A new technology may affect the processes, products and possibly also the capabilities of writing to the extent that what it affords, demands, evokes, guides, supplants or models is profoundly different (yet manageable) from its predecessor. Word processors do not meet this criterion. According to Jonassen (2000), word processors are merely productivity tools that cannot restructure and amplify the thinking of the writer compared with mindtools that can be used to represent knowledge. The computer tool Inspiration (www.inspiration.com), to use one example, has hypertext qualities and thus can be expected to exert strong effects on outlining and writing.

There is an instructional corollary to this lesson. The value of computer technology for the improvement of children’s writing and for the cultivation of writing-
related capabilities greatly depends on the extent to which its employment amplifies, activates, models, supplants or guides cognitive processes that are germane to the process of writing, on the one hand, and different from the ones affected by other technologies, on the other. The relative effectiveness of some of the guidance-providing tools described earlier results from the fact that the processes they modeled and offered for “internalization” were both necessary for better writing to take place and – relative to practical alternatives – novel.

The examination of writing when embedded within novel learning environments leads to yet another lesson to be learned. Research on word processing approached the tools as a given, something akin to a natural phenomenon, the effects of which can be studied “as they are”. The question asked was how does the use of word processors affect writing, without, in most cases, trying to deliberately design computers or their use to serve particular instructional purposes. In comparison, research on writing-related guidance did not treat the computer as a given; the strength of that research was in the way it treated computers as tools that can be designed for instruction. The same applies to instructionally-oriented outliners and idea organizers. The design of novel learning environments went even farther than that by designing whole classroom cultures in which computer-based writing through communication played an important role. There is thus a big difference between studying what computers do and what computers can be made to do. It is the difference between what Herbert Simon (1982) has defined as the study of the natural and the study of the artificial, respectively. The study of the artificial deals “not with the necessary but with the contingent - not with how things are but with how they might be” (Simon, 1982, p. xi). Thus, designs capitalize on computers’
potential strengths, such as their built-in intelligence, their motivating power, or their language-parsing ability, to see how and to what extent they can be made to make a difference.

The study of computer writing and children can of course be fit into both the science of the natural and the science of the artificial. Studying computers and children's writing in the tradition of the former would contribute to a deeper understanding of how culture and technology relate to cognition and literacy; studying what computers can be made to do to children's literacy would contribute to the field of literacy education.

There is another possible lesson to be learned from the difference between the two approaches, a lesson bearing on the distinction we have made between effects with and of the computer. This lesson has wider implications for literacy education. We have seen that computers can be made to have reliable effects on writing during their use (effects "with"). But there is only very little evidence to show that their use, even with built-in guidance and even when embedded within novel learning environments, has lasting and generalizable effects on writing-related capabilities or dispositions. Only a few studies showed transfer effects on writing-related metacognitive mastery or on writing quality in the absence of the tool. One reason for this paucity is that many researchers have taken effects "with" as evidence for effects "of", thus, for example, regarding improved planning or writing quality while being guided by a semi-intelligent tool as if it shows improved planning ability.

But there may be another, far more profound reason that transcends research finesse. The reason is that short term interventions may lead mainly to performance effects "with" a computerized tool, effects that are contingent on the presence of the tool:
More and better planning, more ideas, better essay organization, more meaningful editing, and the like. For more lasting and generalizable effects “of” writing with a tool — better planning ability, a disposition to shift from “knowledge telling” to “knowledge transforming”, and the like, one would need a far longer time span.

It appears that hardly any effects on writing-related capabilities and dispositions can be attained in a “shot in the arm” like instructional manner. Nevertheless, writing with computers is here to stay and evolve. Bolter’s (1991) “writing space”, which was limited to the permanent record left by the pen or typewriter, has acquired additional features, such as: an editable memory for ease of transforming the recorded ideas; variation of fonts and markings for communicating subtleties of tone and emphasis; hyperlinking for pointing to additional relations within and beyond the produced text; an easy accommodation of non-textual material, such as tables, graphs, pictures, and video and voice clips; and, integration of the main writing tool, the word processor, with presentation, transformation, organization, and communication tools. While the new technologies are yet not matured, and many features may be superfluous or in need of further refinement, the little “teche” (Ellul, 1964) is already sharpening his or her craft.
References


Bruce, B., Michaels, S., & Watson-Gegeo, K. How computers change the writing
process. *Language arts, 62,* 143-149.


Davies, G. (1989). Discovering a need to write: The role of the teacher as collaborator. In M. Styles (Ed.) *collaboration and writing.* Milton Keynes: Open UP.


<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computers and Writing</td>
<td>351</td>
</tr>
<tr>
<td>Gavriel Salomon, Ely Kozminsky, &amp; Merav Asaf</td>
<td>351</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>351</td>
</tr>
<tr>
<td>Introduction</td>
<td>353</td>
</tr>
<tr>
<td>Computers and Writing</td>
<td>353</td>
</tr>
<tr>
<td>Different kinds of “effect”, different usages of technology</td>
<td>355</td>
</tr>
<tr>
<td>Word processors</td>
<td>358</td>
</tr>
<tr>
<td>Instructionally-guiding tools</td>
<td>360</td>
</tr>
<tr>
<td>The design of whole new learning environments</td>
<td>366</td>
</tr>
<tr>
<td>Lessons to be learned</td>
<td>372</td>
</tr>
<tr>
<td>References</td>
<td>378</td>
</tr>
</tbody>
</table>