
Background:
Numerous studies affirmed that the capacities of word processing facilitate text generating, revising, and editing. With the convenience of spell-checking, block moving and deleting, formatting, thesaurus, and storage of information, students rearrange written texts much easier as compared to pen-based writing. Consequently, students revised more. However, the results of some research were inconsistent. Many studies found that the quality of computer-written essays has been rated higher than for comparable hand-written essays. Others found no significant differences in the quality of writing produced in the two writing media. The inconsistent findings may be attributed to ill-designed studies, variation in students’ abilities and task types.

Purpose of the study:
The present study investigated the influence of word processing on the writing of students of English as a second language (ESL) and on writing assessment as well. The research questions are posed to assess whether ESL writers
1. pay more attention to higher order thinking processes when writing on a computer or when writing with pen and paper;
2. make more higher level revisions when writing on the computer or when writing with pen and paper;
3. create essays of higher quality on the computer or with pen and paper.

Methodology:
Participants:
Twenty-one adult Mandarin–Chinese speakers with advanced English proficiency living in Toronto participated in the study.

Data collection:
• Each participant wrote two comparable writing tasks under exam-type conditions—one on a Macintosh computer that traced and recorded their writing and revision processes and the other written with pen. For the pen and paper-based session, students were advised to cross out any unwanted parts of their writing, instead of using eraser, so that researcher could examine the change of the text.
• The order of using the two different writing media was randomly decided. Half of the students wrote on the computer for the first session then with pen and paper for the second session, while the other half wrote in the opposite order. It was also randomly decided for each student which topic would be used for computer writing and which topic would be used for handwriting.
• For both writing sessions, the researcher used a cassette recorder to audio-tape the verbal think-aloud protocols. Students were encouraged to think aloud in the language they preferred, either Mandarin or English.

Data processing and analyses:
All discourse was segmented into think-aloud units and coded into six categories of decision-making episodes:

1. pre-planning
2. in-process planning
3. searching for the right words or phrase
4. reasoning about linguistic choices
5. evaluation
6. considering spelling

All hand-written essays were typed out. All essays, both hand and computer-written, were later printed out in the same font and size on a laser printer. Two raters, experienced ESL educators studying in Education doctoral program, rated five aspects of the essays: communicative quality, organization, argumentation, linguistics accuracy, and linguistic appropriacy, according to the nine-point analytic scales developed by Hamp-Lyons (1991). The inter-rater reliability between the two raters was .89.

Results:
Students spent significant more time pre-planning their hand-written than their computer-written essays. However, the proportion of searching for words or phrases, evaluation of the written texts and decision-making episodes, to the total think-aloud episode was significantly higher in computer. There was no significant difference between the two writing media in in-process planning and reasoning about linguistic choices. It was found that participants paid more attention to higher order thinking activities while evaluating their written texts in the computer session, that they revised significantly more at most levels on the computer, and that their computer-generated essays received higher scores in argumentation than the hand-written ones, suggesting that educators should seriously consider the impact of computers on writing assessment.

Discussion:
At the sentence level, participants demonstrated different revision styles: they inserted sentences in diverse places throughout computer-generated essays, whereas in the pen-and-paper writing, they only inserted sentences at the end of a paragraph, where there was more space. Noticeably, students tended to write shorter essays when writing by hand than when writing on the computer. These findings support earlier studies that word processors helped developing writers to revise more, including higher level revisions. They resonate the assumption by Pennington (1996) that given the right writing environments, developing writers, especially those who are adept word processing users, can benefit from writing on computers. They can better mediate their writing activities to write more easily, and better.

Usefulness of this study:
The results showed that students had adapted their composing abilities to the new writing medium. However, many tests of English still remain in the traditional pen-and-paper mode. Vygotsky (1978) claimed that human beings create and utilize tools to extend their capacity to better understand and to regulate the world. Such tools, in turn, change the ways in which those who use the tools conceive of. The present study reminds educators to rethink of the format of classroom assessment.