Web-based Interactive Writing Environment: Development and Evaluation

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ABSTRACT

This study reports the development and evaluation of a web-based interactive writing environment designed for elementary school students. The environment includes three writing themes, "*story pass on*", "*story chameleon*" and "*thousand ideas*", to encourage reading comprehension, creativity and problem-solving skills of students. Three assessment mechanisms, *expert assessment*, *self-assessment* and *peer assessment*, are also designed to provide constructive comments to foster students to review and criticize other writers' essay, to enable students to review their own essay to find strengths and weaknesses in writing, and to encourage students to improve their writing skills. The writing environment comprises four functional modules – writing, assessment, tool and system management. The system was integrated with multilayer educational services platforms, which are designed to support the establishment of online social learning communities for K-12 students and teachers. The system logs and assessment results have been analyzed through the system usage over two years. The results reveal that students can improve their writing skills by participating in the writing environment, submitting many essays, interacting with other students online and reviewing other essays. The comparison result of early and late student writing also demonstrates the improvement of writing. Analysis of the assessment mechanism reveals that expert assessment and peer assessment do not significantly differ. It appears that the assessment criteria proposed in this study fit the needs of both the expert and elementary school students. It is convinced this writing environment effectively helps students to write with designed social interaction, creative writing themes, and reflective assessment criteria.

Keywords

Online writing, Web-based learning environment, Assessment criteria, Peer assessment, Self-assessment

Introduction

Writing represents literacy, and its teaching in the classroom is thus essential to improve students' literacy (Almog & Hertz-Lazarowitz, 1999). In a conventional classroom writing environment, students work on an assigned topic within a limited period of time and accept the teacher's guidance and interpretation on how to write well. After receiving submissions from students, the teacher reviews works. Students generally receive feedback only from the teacher. Writing itself is more a teacher-oriented job than a student-oriented task.

Integrating information and communication technologies into a computer-based writing environment can enhance interactions among students and the teacher over the conventional writing environment. Studies have

shown that the writing with a computer rather than using pen and paper can reduce students' errors (Grejda & Hannafin, 1992) and increase the writing quality (Breese *et al*., 1996; Lam & Pennington, 1995). Studies dealing with automated essay scoring (AES) demonstrate that employing natural language processing or artificial intelligence techniques can provide students with appropriate feedback to automatically advise them about ways of improving their writing skills (Burstein *et al*., 2004; Burstein *et al*., 2003; Shermis & Burstein, 2003). The AES systems provide tools for analyzing the grammar, usage, mechanics, and discourse structure of student essays. Most AES systems are used for large-scale assessments testing writing ability.

A web-based writing environment can improve students' writing skills over the conventional writing environment. For example, students can easily review and learn from each other's work. The anonymity of the Internet may help motivate students to review other students' work. Additionally, various Internet features, such as interactive discussions, enable students to interact with each other and with the teacher. Teachers can constructively criticize students' work. Lin (1997) summarized the advantages for a web-based writing environment as: enabling students to inspect and learn from each other; enabling students to give and receive feedback; enabling students to publish their work, and providing a good editing environment for students, and providing a learning environment.

The objective of this study is to develop and evaluate a web-based writing environment encourage and improve elementary school students' writing. The writing environment incorporates various writing themes and assessment mechanisms to help students to develop good writing skills. The overall system design principles include: to enhance interaction, to provide opportunity to observe, to set up standards for writing reviewing, and to attract students to write by providing them challenging themes. The proposed system was evaluated by examining the system log data over two years, with assessment results and a get-together activity.

Literature review

Generally, the writing process was understood on a linear order model until 1970 (Daiute, 1985). However, this model over-simplifies the writing process, by emphasizing the result rather than the cognitive process of writing. Investigating the writing process from the perspective of cognitive psychology, Flower & Hayes (1980, 1981) proposed the prominent *writing process model*. In this model, composing is seen as having three major components – *the composing processor*, *the writer's long-term memory*, and *the task environment*. The composing processor includes three operational sub-processes, *planning*, *translating* and *reviewing*, which are controlled by a *monitor*. The planning process includes setting goals, and generating and organizing ideas. The translating process translates the writer's ideas into words. Reviewing, including evaluating and editing the content, is the most important part of the composing processor. Reviewing occurs, for example, when a writer is unhappy with his work, considers alternative ideas, or does not plan his work successfully. These three sub-processes do not occur in any particular order. A writer might be writing, moving his ideas and discourse forward, then immediately backtrack, rereading and digesting what he had written. These sub-processes are recursive, with one often interrupting the other, represented a shift in the understanding of the writing process (Gillespie, 1999). The writer's long-term memory and the task environment provide resources and stimuli for the composing processor. Ideas in the planning process are turned into words by the translating process and then reviewed in the reviewing process.

In contrast to the role of cognitive processes in student writing skills, some studies have investigated the influences of social or motivational process on writing (Hidi & Mclaren, 1991; Hidi *et al*., 2002; Renninger *et al*., 2002). Bruning & Horn (2000) suggested that four conditions are necessary to enhance the motivation to write. These four conditions include nurturing functional beliefs regarding writing, fostering student engagement through establishing authentic writing goals and contexts, providing a supportive context for writing, and creating an emotional environment conducive to writing. Hidi *et al*. (2002) added another aspect, namely, ensuring that children have sufficient knowledge of the contents of the topics they were asked to write about, and examined the design procedures to improve student emotional and cognitive experiences during argument writing.

During the writing process, the most important of all is to cultivate the reviewing skill. That is, to be able to correct one's own spelling, and to substitute words and phrases or even rewrites his entire work. Writing is also a social activity, in which social learning helps individual learning, cognitive structure and interaction (Bereiter & Scardamalia, 1987). To help cultivate students to review, observation and peer assessment in social learning (Falchikov, 1995; Topping, 1998; Rada, 1998; Lin *et al.*, 2001; Hertz-Lazarowitz & Bar-Natan, 2002) is adopted to design the assessment criteria. Through interactive assessment of themselves and their peers, students will

have the chance to read, draw upon, correct and challenge one another's work, enabling them to gradually reflect upon reviewing criteria.

In writing, studies have shown that the narrative mode of writing is easier for students to understand than the exposition mode, even though the two modes are equally complex (Graesser *et al*., 1980). A study has also shown that children agreed narrative writing mode is easier than exposition writing, because children most often read narrative texts (Tsai, 1996). For instruction purpose, in this study the authors adopt both genres. Assessments of children's writing have divided the criteria either of the narrative or of the exposition modes into three main categories: mechanical (including grammatical), organization and information. Under each category, items are listed to define the category. Items will be elaborated later in this paper.

System design principles

An expert, a well-known writer of children's literature in Taiwan, helped design and implement the writing environment. The expert proposed topics in three writing themes. During two-week periods, students wrote essays on writing themes of their choice. The expert checked the website frequently, and assessed and commented on all submitted writings.

Writing themes design

Three writing themes were designed to encourage students to improve their reading comprehension, creativity and problem-solving skills. The first writing theme, "*story pass on*", is designed to foster students' reading comprehension and logical thinking. Figure 1 illustrates the operational model of "*story pass on*." The expert starts a story, which students take turns to continue by adding new paragraphs. Therefore, a student must adequately comprehend the previous paragraphs to add a new paragraph, in order to form a well-organized story. To terminate each story on a specific date, a complete story comprises four paragraphs, meaning that a story is completed in four turns. Hence, a new story begins every two months for "*story pass on*."

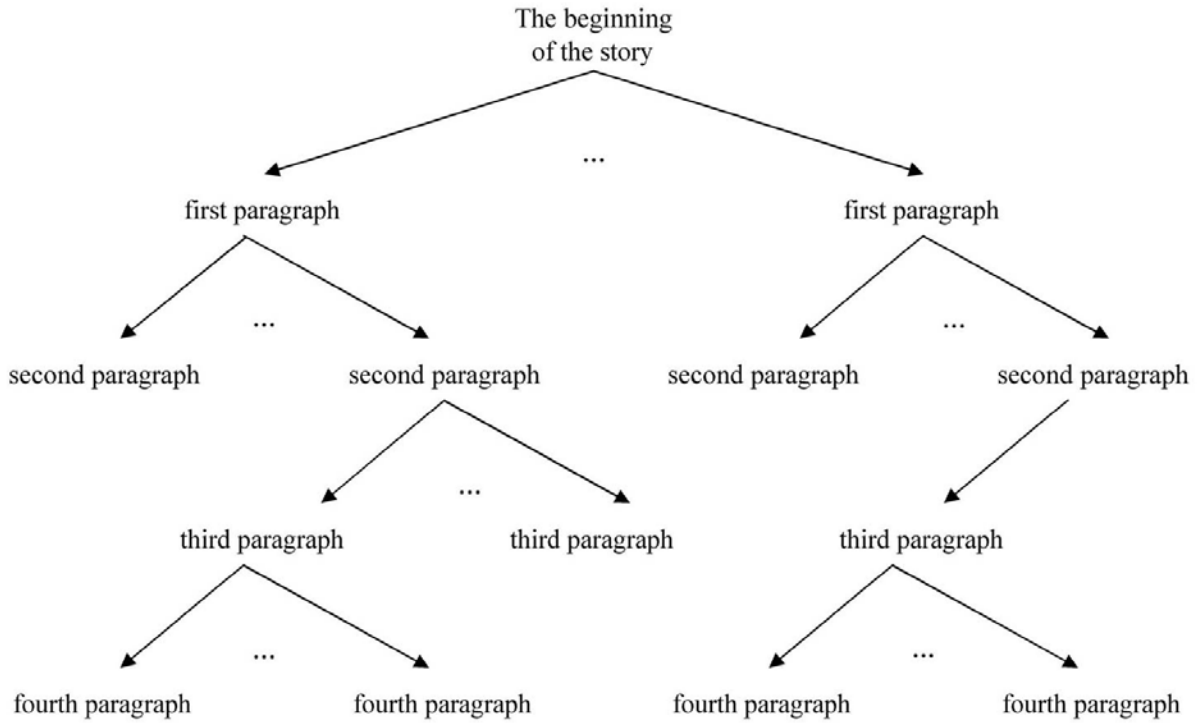

Figure 1. The operational model of "*story pass on*"

The second writing theme, "*story chameleon*", is designed to foster students' creativity. Students are expected to rewrite a well-known story, preserving its original essence but giving it a new flavor. Students are advised to adapt some factors in the story such as characters, times, places and plots. The third writing theme, "*thousand*

ideas", is designed to train students to write expository text that describes how to solve a problem. Students are asked to write about problems in daily life and their solutions. Students are expected to propose solutions to problems and express their thoughts expositionally. Table 1 summarizes the three writing themes and their related characteristics.

Table 1. The three writing themes

Writing theme	Mode	Duration	Fostering ability
Story pass on	Narrative	Two weeks for a paragraph, two months for a complete story	Reading comprehension & logical thinking
Story chameleon	Narrative	Two weeks	Creativity
Thousand ideas	Exposition	Two weeks	Problem solving

Assessment mechanisms design

This study designs three assessment mechanisms, *expert assessment*, *self-assessment* and *peer assessment*. The expert assesses and constructively comments on students' writing to improve their writing skills. The expert also chooses good writings, showing students how to write well. The self-assessment enables students to find their strengths and weaknesses in writing. The self-assessment process reflects the *writing process model* reviewing process. The peer assessment teaches students to review writing and give critical comments to others. During the peer assessment process, students learn to appreciate others' writings and extend their views to write.

The criteria for writing assessment include three categories: (1) mechanical (including grammatical), (2) organization (transition and continuation), and (3) information. In each category, three to four items elaborated the area are listed and explained. For example, in mechanical, there are: (1-1) Spelling and grammar are correct; (1-2) Words and phrases are not repeated; (1-3) Words and phrases used are vivid. Examples are provided following each item. Each item is evaluated on a five-point scale score which represented by words instead of score for easy understanding. The word descriptions are "Great! Perfect!", "Good! But might better than this.", "OK! Average.", "Not so good! Need more efforts on writing.", "Sorry! Unacceptable.", from higher score 5 to lower score 1. Reviewers could also comment on each reviewed work.

The assessment criteria are explained by the writing genre (narrative or exposition). Based on the assessment categories described earlier, assessment criteria are adopted and tested to fit elementary school level. Tables 2 and 3 list assessment criteria of the two writing modes, respectively. Moreover, an additional assessment item is added to each writing theme to evaluate its attribute as shown in Table 4.

Table 2. Assessment criteria for "*story pass on*" and "*story chameleon*" (Narrative mode)

Category	Criteria	Description
Mechanical	Elegant words	Using appropriate words and phrases
Organization	Clear paragraph	Making a clear paragraph
Organization	Coherence	Making coherent relation from the beginning to the end of the writing
Organization	Title consistent	Making sure that the content of the writing is consistent with the title
Information	New and original	New and original ideas on writing

Table 3. Assessment criteria for "*thousand ideas*" (Exposition mode)

Category	Criteria	Description
Mechanical	Correct grammar	Correct use of words and phrases with correct grammar
Organization	Vivid writing	The style of writing is smooth and clear, the content of writing is vivid
Organization	Abundant sentence	Using various words and phrases with abundant sentence
Organization	Coherence	Making coherent relation among paragraphs
Organization	Strong beginning	Providing persuasiveness sentences at the beginning
Information	Reasonable elaboration	Making reasonable illustrations and descriptions
Information	Abundant arguments	Using various examples, opinions and thoughts to express the theme
Information	Original view	New and original ideas
Information	Simplicity	Simplifying sentences to express important thoughts and making it easy to understand

Table 4. Additional assessment criteria for each writing theme

Writing theme	Criteria	Description
Story pass on	Smooth connection	The plot of the story is smoothly connected to the previous paragraph
Story chameleon	Originality	The rewritten story is new with original ideas
Thousand ideas	Problem solving	The proposed solution can solve the problem

The writing environment

Figure 2 illustrates the system architecture of the web-based writing environment. The writing environment comprises four functional modules, *writing module*, *assessment module*, *tool module* and *system management module*. The server was implemented on the Sun Solaris operating system with an Apache Web Server using the MySQL database to store log data such as individual student information as well as student submitted essays and scores in the three assessments. The system was developed using the PHP and Java Script programming languages. The system was integrated with the EduXs platforms, which are multilayer educational services platforms designed to support the establishment of online social learning communities for K-12 students and teachers (Chan *et al*., 2001; Chang *et al*., 2003). The system was integrated user accounts for log on to the system with the EduXs platforms using a Cookie mechanism so that users can use a single account to log on to different systems via the platforms. Through this integration, the online virtual learning community of the system is linked to the real world social learning community since virtual communities are mapped to real social communities on the EduXs platforms.

The target users of the writing environment are elementary school students. The system identifies users when they log on to the system. Only the target users can submit their work using the system. Other users can login and browse the web pages of the system and interact with others in the discussion boards, but cannot submit work.

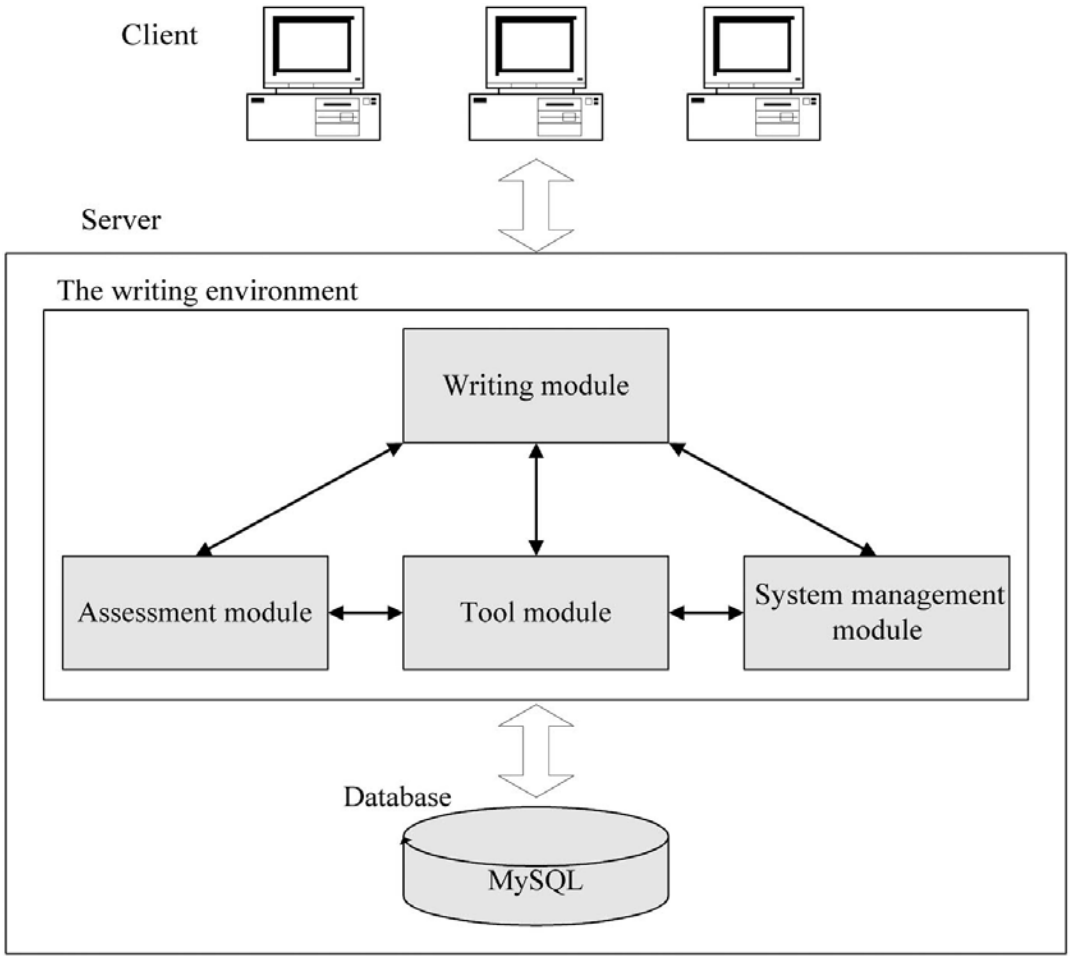

Figure 2. System architecture of the web-based writing environment

Writing module

The writing module provides an online writing environment for students on the three writing themes. For "*story pass on*", a complete story is composed in four paragraphs. For each writing topic during a two-month period, all paragraphs are displayed as a four-level tree structure in paragraph order. Figure 3 presents a screenshot of the tree structure with the corresponding English translation. Students can compose paragraph by following their own paragraphs or connecting to others' paragraphs, and can compose several paragraphs connected to a same previous paragraph. By clicking any paragraph, a student can read it and decide whether to connect a new paragraph to it. When a new paragraph is composed and submitted, it is immediately appended to the appropriate position on the tree structure according to its content. Students can easily understand the relationships among all paragraphs through the tree structure. For "*story chameleon*" and "*thousand ideas*", all works must be submitted during a half-month period. Therefore, the two writing themes have only a single level for the tree structure in the order in which work is submitted.

Figure 3. A screenshot of the tree structure (left) with the English translation (right) for "*story pass on*"

Assessment module

The assessment module provides user interfaces for the three assessment mechanisms. When a work is submitted, links to the three assessment interfaces are displayed. In the expert assessment interface, the expert assesses work by giving constructive comments and scores. The good writings are labeled 'good', which serve as samples for other students to read and reflect. Self-assessment and peer assessment use the same interface. The system determines the form of assessment from the student's account. A web page summarizes the results of the three assessments with the assessment criteria. Students can look at the scores and comments by the expert and peer(s), and compare these results with those from self-assessment, enabling them to further reflect on their work. To make assessments reliable and valid, students cannot view the expert and peer assessments before they review a work. And the reviewer's name is not displayed.

Tool module

The tool module provides tools to facilitate and motivate students' writing. The system provides four tools.

- *Thesaurus*: Most published thesauruses are designed for adults, with words and phrases explained in ways which children might not understand. Therefore, children cannot clearly distinguish words and phrases using adult thesauruses. In this study, a thesaurus was built with common words and phrases for elementary school students, including a total of 4,346 common words (Chinese characters) and 8,331 common phrases. The common words are made based on the announcement of "*common words for elementary school students*" by the Taiwanese Ministry of Education, while the common phrases were found from studies in which students make their phrases from the common words, and the common phrases are determined by the frequency of use (Ko & Yin, 1990; Ko *et al*., 1990). The thesaurus also provides synonyms and antonyms for common phrases. Students can use the thesaurus to search for phrases from a common word, and for synonyms and

antonyms from a common phrase. Thus, the thesaurus teaches students new words and phrases to enrich their writing.

- *Personal data management interface*: This tool enables users to manage their personal data, which include individual bulletin boards, discussion boards, writing records and registered data. The individual bulletin board displays system messages and self- and peer assessment results. Once a student submits his work, he can request a manager of an individual discussion board to lead a discussion topic related his essay topic. The system provides an interface for students to manage their own discussion boards enabling them to focus on the discussions, motivating students on writing topics. Each individual writing record displays a particular student's essays, enabling anyone to review his previous work. Individual registered data, such as nickname, status, name of school, grade, telephone and address can be edited.
- *Searching interface for good writing*: The system provides a searching interface for students looking for good works. Students can search on various items including writing theme, topic, duration, writer, school and grade. The content of writings of the hit results are shown.
- *Ranking boards*: A ranking board can help motivate learners use a system. The system contains six ranking boards to encourage students to participate in the writing community. The boards display high-achieving schools' and students' names and achievements. The *diligence ranking board* ranks students by the number of works. The *school ranking board* ranks schools by the number of works. The *good writing ranking board* ranks students by the number of works assessed by the expert as good. The *peer assessment ranking board* ranks works by peer assessment. The *reviewer ranking board* ranks students by the number of works reviewed. Finally, the '*discussion board' ranking board* ranks students by the number of messages they post on the discussion board.

System management module

The system management module provides system resources management interfaces and developer and expert settings. This module manages student accounts, bulletin boards, discussion boards and ranking boards. The expert also uses this module to publish and maintain the three writing themes, for example, by publishing new writing topics, deleting inappropriate writings and replying to questions in the discussion boards.

Comment from the expert

The expert individualized comments for students. The comments can be divided into the following categories.

1. Indirect encouragement – "Wow, it takes a tremendous trouble to show the idea. Please keep on this interesting topic."
2. Bringing up concrete comments –
    - "Presented the reasonable cause and effect, it is very persuasive."
    - "It never occurred to me that you would connect the conclusion with the original topic in such a sharp way. GOOD JOB!"
3. Suggestions for improvement –
    - "There are lots of ways to present an abstract idea, try to make it more readable."
    - "Writing is not like keeping a diary, make ways for readers is one of the responsibilities of a writer."
4. Indirect clarification of moral values –
    - "It is a very special ending. If you were the person, would you choose to wander in the dream for it is a beautiful dream to experience the reality… to accomplish yourself?"
    - "You do not have to sacrifice others, you can create the chance of win-win situation."
    - "It is a very positive and active attitude, using the viewpoint to look yourself, your life, and the world will be just wonderful. You will feel happy too."

The expert employed a reader's tone rather than a teacher's tone to make comments. For example, "Please present your thought by paragraphs instead of a single block, it is tiring to read without paragraphs. Remember to segment your writing when submitting next time, is that ok for you?" Sometimes the expert would use a more serious tone to indicate a lack of progress here, for example, "The above two paragraphs are very interesting. Compared with them, this paragraph seems rather dull." However, the students expect feedback from the expert. After submitting a work, a student often left messages for the expert, like, "Read and give comments, I have sent my writing for *story pass on*."

Evaluation

Since this writing environment is not compulsory, students could come and go as they wish. It is not easy to carry out a formal evaluation of its function. Nevertheless, the authors could observe the students behaviors on Internet to see: their frequency of submitting writings, their frequency of assessing other's writings, the content of discussion board. All these behaviors could illuminate students' interest in our design. In particular, the authors could also examine if the design principles were caught on by the students.

This section describes three analyses on the system usage, the *system log analysis*, *assessment result analysis* and *description of a get-together activity*. The system log analysis describes the system usage from the system log file in various perspectives, in particular including a comparison of early and late student writing. The assessment result analysis describes results of analyzing the three assessment mechanisms. These two analyses were performed in two years from November 1, 2002 to October 31, 2004. The get-together activity was a face-to-face activity for schoolteachers and students involved in the writing environment. Students' experience and feedback on the writing environment were also analyzed.

System log analysis

Registered users

In total, 3,695 users were registered on the system, of which 2,510 were elementary school students from 257 different schools. The students were invited by schoolteachers or parents, or found the site themselves while surfing the Internet. The distribution of elementary students for each grade was: grade 1: 68, grade 2: 75, grade 3: 220, grade 4: 766, grade 5: 714, and grade 6: 667 (The number shows the distribution of current users. The system had operated for two years and some original elementary school students became junior high school students. Their writings are not included in the following results). Thus, more higher-grade students than lower-grade students registered for the writing environment. Most of the users were found to be fourth to sixth graders.

Submitted students and writings

Table 5 shows the numbers of submitted students and writings with writing themes and grades. More students submitted work to "*story chameleon*" than to the other two themes; while more works were submitted to "*story pass on*" to the other two themes. The submission ratio can be calculated from the numbers of submitted writings to students. The submission ratio was found to be highest in "*story pass on*", even though this theme did not have the most submitting students. The reason could be attributed to the following. A complete story in "*story pass on*" has four paragraphs. Students continue to write their paragraphs to make a complete story because they are interested in the story's progress. This finding demonstrates that "*story pass on*" effectively encourages students to write. Additionally, although "*story chameleon*" has the most submitting students, it has the lowest submission ratio, perhaps due to the task complexity for requiring elementary school students to think creatively within an old framework. It is not an easy job for them.

In terms of grade, first and second graders show low submitted student numbers and submission ratio, while third graders show low submitted students but high submission ratio. By contrast, fourth graders, though forming the largest number of submitted students, have a low submission ratio; fifth and sixth graders are comparatively high in both the number of submitted students and submissions, as well as the submission ratio. Sixth graders were found to have the highest submission ratio. Further analysis of the system log data shows that some fourth graders were assigned by teacher to complete their homework using the system, leading to the large number of submitted fourth-grade students. However, most fourth-grade students only submitted once and did not carry on writing. By contrast, fifth and sixth graders were found to be interested in writing and used the system voluntarily. These findings indicate that those who write are those who are motivated by interests in this writing environment. Those who are required by assignments will not stay long.

The ratio between writing themes and graders show that first, second and third graders like to use "*story chameleon*", while fourth, fifth and sixth graders prefer "*story pass on*". This result implies that lower graders are interested in rewriting stories, while higher graders prefer to pass on stories and are willing to keep on writing.

Table 5. Submitted students and writings*

	Story pass on			***Story chameleon***			***Thousand ideas***			**Total**		
Grade	Student	Writing	Ratio	Student	Writing	Ratio	Student	Writing	Ratio	Student	Writing	Ratio
1	12	15	1.25	6	10	1.67	10	14	1.40	24	39	1.63
2	4	4	1.00	4	5	1.25	1	1	1.00	8	10	1.25
3	20	27	1.35	22	58	2.64	24	52	2.17	43	137	3.19
4	105	179	1.70	111	163	1.47	82	135	1.65	210	477	2.27
5	79	217	2.75	99	198	2.00	87	194	2.23	176	609	3.46
6	71	209	2.94	68	120	1.76	81	151	1.86	133	480	3.61
Total	280	651	2.33	297	554	1.87	272	547	2.01	567	1,752	3.09

**Since the same student might submit to different writing themes, the sum of numbers of students in three writing themes does not equal to the total number of the three individual numbers. Additionally, a student may not have made a submission in over a year during which, the student has moved up a grade placing his submission into a different grade. Therefore, the sum of students in each grade does not equal to the total number of the six individual numbers.*

Good writings

Table 6 shows the numbers of submitted writings and "good writings" as chosen by the expert with writing themes and grades. The result shows that over 70% of the works were considered to be good. As for the writing themes, works in "*story chameleon*" were less likely to be considered good than those in the other writing themes, perhaps because of the creativity required in rewriting making it very tough for most students. Writings in "*thousand ideas*" were mostly considered to be good, indicating that students have good solutions for daily life problems. Although the writing mode for "*thousand ideas*" is expositive, which is more difficult than narrative writing for elementary school students, the finding demonstrates that writing about daily life problems and solutions can prepare students for writing exposition.

As for the grades, generally the higher the student's grade, the better the writing. Quality and student's grade showed a positive correspondence. The ratio of good writings and of submission from each grade was also found to be positive. The result indicates a positive correlation between students' submission ratios and their performance in writing using the system.

Table 6. Submitted and good writings

	Story pass on			***Story chameleon***			***Thousand ideas***			**Total**		
Grade	Writing	Good	Ratio	Writing	Good	Ratio	Writing	Good	Ratio	Writing	Good	Ratio
1	15	7	46.67%	7	3	42.86%	17	8	47.06%	39	18	46.15%
2	4	2	50.00%	5	2	40.00%	1	0	0.00%	10	4	40.00%
3	27	18	66.67%	58	33	56.90%	52	38	73.08%	137	89	64.96%
4	179	106	59.22%	163	84	51.53%	135	103	76.30%	477	293	61.43%
5	217	159	73.27%	198	124	62.63%	194	175	90.21%	609	458	75.21%
6	209	167	79.90%	123	90	73.17%	148	126	85.14%	480	383	79.79%
Total	651	459	70.51%	554	336	60.65%	547	450	82.27%	1,752	1,245	71.06%

Comparison of early and late student writing

To further examine whether students' writing skills improve, the authors compared early and late student writing. The data used for analysis were the scores evaluated by the expert to the essay of each student. Before the analysis, the data was pre-processed as follows. Items for students who had only submitted one essay were

deleted, because they could not be used for comparison. Items for students who had submitted essays only within two weeks (two months for "*story pass on*") were also deleted. That is, the first and the last essays are submitted within two weeks (two months for "*story pass on*") were not used for the analysis because the duration for one topic in the writing environment is two-week long (two months for "*story pass on*"). Scores for early writing were calculated based on the average of scores of early student writing within two weeks (two months for "*story pass on*"), and scores for late writing were calculated based on the average of scores of late student writing within two weeks (two months for "*story pass on*"). Following the pre-processing, a T test analysis (2 tailed) was performed to compare the scores for early and late student writing. Table 7 summarizes the comparison of the early and late student writing for the three writing themes. The comparison results show significant differences between early and late student writing for "*story pass on*" ($t=-2.936$, $df=43$, $p=0.005<0.01$), and for "*thousand ideas*" ($t=-2.642$, $df=41$, $p=0.012<0.05$). These results demonstrate that students have improved their writing skills by using the writing environment. However, no significant difference was found for the result for "*story chameleon*" ($t=-1.305$, $df=37$, $p=0.200>0.05$). The reason for this lack of any difference may be the fact that rewriting is a creative task which is very tough for most students, as mentioned earlier.

Table 7. Comparison of the early and late student writing for the three writing themes

	Story pass on		*Story chameleon*		*Thousand ideas*	
	Early writing	Late writing	Early writing	Late writing	Early writing	Late writing
N	44	44	38	38	42	42
Mean	3.43	3.60	3.46	3.56	3.52	3.71
SD	0.28	0.30	0.36	0.38	0.38	0.29

Ranking boards

Table 8 shows the analytical results the ranking boards. The table lists the students' accounts (in abbreviation) with their corresponding ranking numbers in different boards. Each ranking board measures a different characteristic of the student or school. The *diligence ranking board* ranks students by number of works submitted. The *good writing ranking board* ranks students by the number of good works submitted. The *peer assessment ranking board* ranks students by favorable reviews obtained for their works. The *reviewer ranking board* ranks students by number of reviewing comments made. The '*discussion board' ranking board* ranks students by contributions to online discussions. The results of Table 8 clearly show that the rankings of names on different boards were similar, indicating that more writing, reading, reviewing, discussing and interacting lead to good writing. In other words, writing is improved through involvement in the writing environment, making many submissions, interacting with other students online and reviewing other works.

Table 8. Analytical results of the ranking boards*

Ranking board / Ranking	***Diligence***	***Good writing***	***Peer assessment***	***Reviewer***	***Discussion board***
1	FK (76)	FK (64)	FK (62)	S4 (78)	JO (102)
2	OU (49)	OU (43)	OU (47)	RI (59)	FK (76)
3	A0 (40) SA (40)	SA (37)	SA (45)	OU (50)	CL (63)
4	PE (35), S4 (35)	A0 (34)	JO (30)	JO (48)	OU (48)
5	JO (31), ZO (31)	PE (31), S4 (31)	A2 (29)	SA (42)	A2 (47)
6	LK (30)	ZO (29)	DY (27)	S8 (40)	PE (42)
7	A2 (29), AN (29)	JO (27)	LK (26)	S7 (35)	ST (30)
8	DY (26)	A2 (25)	A0 (22), GI (22)	LK (34), N5 (34)	ZO (26)
9	CL (23)	AN (23), CL (23), DY (23)	PE (21)	DY (31), LI (31), F1(31)	N4 (22)
10	KR (21), RI (21), ST (21)	LK (20), RI (20), ST (20)	S4 (20)	ST (29)	YG (20)

**In the column, the students' accounts (in abbreviation) are listed on the left, and the numbers in the parentheses show the number of writings and the frequency of participating.*

Submitted time

Figure 4 plots the number of writings against time submitted, and shows two peaks in the graph. The first peak locates at 1 pm to 5 pm, when the students are at school, and the second peak locates at 8 pm to 10 pm, when they are at home. Clearly, the students use the system for writing both at school and at home.

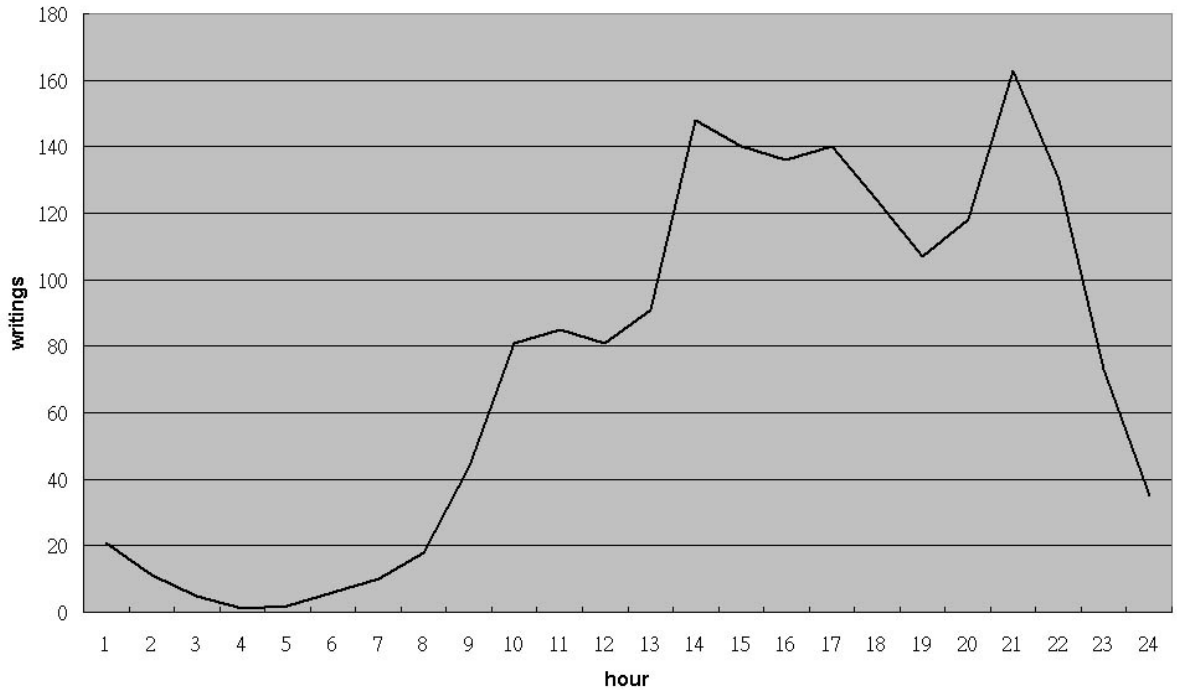

Figure 4. The number of writings and submitted time

Discussion board

From the discussion board content, the responses of students using the system show they got the essence of our design. The content can be divided into four categories (illustrated by quotes from students).

1. Writing topics
   Typical school writing is considered to be formal, conservative and rather dull, causing difficulty in arousing students' interests. Students found topics given by the expert to be much interesting, unique and challenging than typical school topics. Examples include: "… Maybe that's because the topics here are more creative! Usually the topics from the school are rather dull!"; "I cannot agree more. The topics from the school are pretty much the same and I am fed up with it. I can even guess the topic. I prefer the topics here because I can write anything I want. It's a place for your imagination to run wild."
2. Writing appreciation
   Students here can learn something by appreciating others' works. Examples include "The way she describe it is impressive, …" "I think you did a great job here," and "You are fabulous!"
3. Writing community
   Students can enhance their social interaction, improve their ways of thinking and discuss their future goals through discussion and interaction by themselves on the discussion board. For example, Student A wrote "The topic for *story pass on* was difficult. I am good at writing the story on people…well, I think I would give it a try. I am really not good at this, though." Student B then wrote "It takes me like forever to think of this topic…after all I still want to pass it on." However, student C wrote "I feel quite easy as long as I think of it as a person. Everything is somewhat related to human beings after all! Don't give up!"
4. Reflection
   Students occasionally doubt their writing skills, and seek assistance on the discussion board. They ask questions such as "What is the level of my writing skills?" "What topic is more suitable for me?"

Assessment result analysis

Result of self-assessment

Table 9 shows the numbers of submitted writings, self-assessment and peer assessment. The result shows that the ratio of self-assessment to submitted writings is lower than 40% as a whole. In writing themes, "*story pass on*" has the highest ratio and "*story chameleon*" has the lowest ratio in self-assessment. This finding could be due to the lowest submission ratio for higher graders in "*story chameleon*", as described earlier. Self-assessment is dominated by the higher graders. Fourth graders submitted more self-assessment than fifth graders as they form the highest number of submitted students.

Table 9. Submitted writings, self-assessment and peer assessment

a. by writing themes

Writing theme	Submitted writing	Self-assessment	Ratio	Peer assessment	Ratio
Story pass on	651	287	44.09%	466	71.58%
Story chameleon	554	174	31.41%	372	67.15%
Thousand ideas	547	193	35.28%	317	57.95%

b. by grades

Grade	Submitted writing	Self-assessment	Ratio	Peer assessment	Ratio
1	39	7	17.95%	15	38.46%
2	10	2	20.00%	4	40.00%
3	137	46	33.58%	80	58.39%
4	477	176	36.90%	380	79.66%
5	609	205	33.66%	370	60.76%
6	480	218	45.42%	306	63.75%
Total	1,752	654	37.33%	1,155	65.92%

Result of peer assessment

The ratio of peer assessment to submitted writings is over 60% as a whole which is higher than that for self-assessment. This finding shows that students are interested in assessing their peers and often reviewed and assessed other students' works. In writing themes, the ratio is the highest in "*story pass on*" and lowest in "*thousand ideas*", probably because most of the works in "*thousand ideas*" are short, but assessment criteria are relatively long. It might make assessment judgment difficult. Moreover, higher grade students generally assessed more writings. Fourth graders have the highest ratio because they have the highest number of submitted students.

The reliability of assessment mechanisms

Table 10 summarizes the analytical results of the three assessment mechanisms for the three writing themes. Comparisons were done by one-way ANOVA among different groups. The results show significant differences among expert, self- and peer assessments in the three writing themes as "*story pass on*": $F_{(2,1128)}=63.75$, $p<.001$, "*story chameleon*": $F_{(2,781)}=41.67$, $p<.001$, and "*thousand ideas*": $F_{(2,810)}=47.35$, $p<.001$.

Table 10. Analytical result of the three assessment mechanisms

Writing theme		Expert assessment	Self-assessment	Peer assessment
Story pass on	N	446	270	415
	Mean	3.49	4.09	3.39
	SD	0.38	0.88	1.11
Story chameleon	N	314	156	314
	Mean	3.48	4.17	3.33

Writing theme		Expert assessment	Self-assessment	Peer assessment
	SD	0.41	0.90	1.30
	N	374	172	267
Thousand ideas	Mean	3.42	4.15	3.52
	SD	0.37	0.86	1.22

To further understand the relationships among the three assessment mechanisms, Turkey's post hoc test was carried out. Significant differences arose between expert assessment and self-assessment and between self-assessment and peer assessment (all $p<.001$), whereas no significant difference was found between expert assessment and peer assessment in the three writing themes (all $p>.05$).

Self-assessment is different from the other two assessments. As the table clearly shows, average scores are higher for self-assessment than for either expert or peer assessment, perhaps because students are generally unable to identify their errors in writing. Therefore, students tend to give themselves high scores.

No statistically significant difference was found between expert assessment and peer assessment and it is consistent among all three writing themes. This finding demonstrates that the assessment criteria proposed in this study fits the expert and elementary school students. It indicates a certain amount of consensus and objectivity of the assessment criteria posted by the authors.

Relationship between expert and peer assessments

To further analyze how expert and peer assessments are related, the number of works assessed by the expert and peers was calculated. Average scores could range from 1 to 5, according to the five-point scale used in this study. The result from expert assessments for students' writings was divided into three groups. The group with average scores in the range 1.00–2.33 is the *low-scored group*. The group with scores averaging of 2.34–3.67 is the *middle-scored group*. The group averaging 3.68–5.00 is the *high-scored group*. First, the number of works in each group from expert assessment was calculated, followed by the number of works assessed by peers. The result is shown in Table 11.

The ratio of peer assessment to expert assessment in each group is highest in high-scored group, and lowest in the low-scored group. This finding seems to indicate that most students prefer to assess the writings in high-scored group, while those in low-scored group were less assessed by students. The results in the three writing themes are consistent.

Above finding indicates that most students, like experts, can discriminate between good (high-scored) and poor (low-scored) writing. The better the writings (high-scored group), the higher the ratio of students assess. This result also indicates that students read each work, think about its content and have an implicit evaluation of it. When the evaluation is good, then he determines whether to grade it. It clearly shows that the assessment criteria provided in this study can assist students to appreciate good from poor writings and to learn the *reviewing* process in writing.

Table 11. Relationship between expert and peer assessments

	High-scored group			**Middle-scored group**			**Low-scored group**		
Writing theme	Expert assessment	Peer assessment	Ratio	Expert assessment	Peer assessment	Ratio	Expert assessment	Peer assessment	Ratio
Story pass on	143	113	79.02 %	305	166	54.43 %	181	63	34.81 %
Story chameleon	104	92	88.46 %	214	106	49.53 %	197	85	43.15 %
Thousand ideas	158	84	53.16 %	227	117	51.54 %	83	38	45.78 %
Total	405	289	71.36 %	746	389	52.14 %	461	186	40.35 %

Analysis on a get-together activity

Some of the online writers might be curious about the other writers and the expert for its virtual writing environment. Though they probably have read many other students' works, they never have the chance to meet. They would especially like to meet the expert. Therefore, all the writers and the expert, as well as schoolteachers were invited to attend the *get-together activity*. Other reasons for holding this activity were to maintain the momentum of writing motivation, and to promote the online writing environment to schoolteachers. Students were honored by recognizing them as most diligent writer, best writer, most popular writer, best reviewer, and most active contributor in the discussion board. Additionally, to make this activity more meaningful, top students had their works published in a book entitled "*Challenge Writing Environment*" (Ko *et al.*, 2004).

Invited students shared their personal experiences and feedbacks with each other. Those are valuable sources to acknowledge our goals have been accomplished, and can be divided into three categories.

1. Interesting and creative topics
   - LI (sixth grader) – "It's a place you can run your imagination wild. The writing topics given by the expert are very lively and the short opening in the passage which makes me easy to pass on. I feel like I'm playing rather than doing something boring in this writing environment."
   - WA (third grader) – "My favorite is *story chameleon* because I can use my full imagination and creativity, and finish in one go; *Story pass on* is more difficult because you have to be coherent with the topic and you have to continue four times…"
2. Interaction in the writing community
   - LA (sixth grader) – "I want to thank every writer for helping me in this interactive writing environment. It unconsciously improves my writing skills though it is not evident as it shows. However, through interaction with the other students, I can feel my own improvement."
3. Viewpoints toward writing
   - OU (sixth grader) – "It was a difficult task for me to write an essay, especially for the school writing class before I found out this website. While my mom found this website, I felt inspired. The more I write, the better I feel. As long as I sit in front of the computer, I can't stop writing. It is just wonderful."
   - WO (fourth grader) – "I feel writing is much easier than it was before. From the movies, extracurricular reading, the content on the Chinese textbook and my fantasy, I can create many plots and scenes. I can use material from the monkey in Monkey Goes West of the Chinese classics, woodpecker doctor from the Chinese textbook and the magic power I have longed for from Harry Potter."
   - LI (fifth grader) – "I used to get headache when the teacher assigned the writing as our homework. But now, I won't feel that and I become interested in that."
   - LA (sixth grader) – "Because of the writing environment, I feel great improvement in my writing and creation which make me interested in writing a lot more."

Conclusion

This study reported the development and evaluation of a web-based writing environment, which is constructed to be lively, interactive and reflective. The environment is targeted at elementary school students and designed with three versatile writing themes, "*story pass on*", "*story chameleon*", and "*thousand ideas*", to encourage students' reading comprehension, creativity and problem solving skills through writing. Three assessment mechanisms, *expert assessment*, *self-assessment* and *peer assessment*, were included in the writing environment. A well-known children literature writer acts as an expert to interact frequently with students. Helped by the expert and the three assessment mechanisms, students were encouraged to write, review works and comment critically to other students' works, and examine their works to find their strengths and weaknesses in writing.

Since most of the students voluntarily participated in this writing environment, it is difficult to carry out a formal evaluation of students' writing achievement. The authors could only adopt log files to examine the frequency of all kinds of participation. The analytical results of the evaluation, based on analyzing data over two years, demonstrate that involvement in the writing environment, making more submissions, interacting with other students online and reviewing more of other students' works all benefit writing. These results were confirmed by the comparison result of early and late student writing. The study also found that no significant difference between expert and peer assessments. It reveals that the assessment criteria proposed in this study are concrete enough for elementary students to hold the essence of them. When students were guided with the criteria to review other students' writing, it is believed that they would learn to appreciate and to critique other's writings. In return, they would reflect upon their own writings.

Moreover, the writing themes and topics and social community are the important features in the system design, which are the attractions that the students participating in this writing environment. The writing themes are lively and challenging as participated students described. The topics allowed them to ponder, to reason, and to create. As for the community, Bereiter and Scardamalia (1987) had stated, writing is fundamentally a social activity. The authors designed the interactive functions to let students know that they could communicate with readers including the expert, and believe that this factor explains why the elementary school students were willing to write more than once, and to stay with this environment relatively long. The system log data reveals that students continue to use the system to compose their writings on a regular time basis. The longest duration for a student to use the system is almost two years, and the top ten students have used the system over fifteen months. Moreover, students' experience and feedback on the writing environment indicated that they were highly interested the interaction in the writing community provided by the study. In particular, as a result of the writing environment, students who previously thought writing was difficult came to feel writing it was much easier than before.

Based on the outcome of this study, the authors suggest that many-sided topics should be chosen, and social interactive factors should be included, when teaching writing. Furthermore, the writing assessment criteria developed by the authors should be considered as the guidelines for writing reviewing. It helps students learn to read and write reflectively and critically.

For future development, the authors plan to analyze in detail students' writing behavior, and to enhance the present system and integrate it into a classroom-based writing environment to benefit more students who are struggling with writings.

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References

Almog, T., & Hertz-Lazarowitz, R. (1999). Teachers as peer learners: Professional development in an advanced computer learning environment. In A. M. O'Donnel & A. King (Eds.), *Cognitive perspectives on peer learning*, Hillsdale, NJ: Erlbaum Press, Ch 12, 285-313.

Bereiter, C., & Scardamalia, M. (1987). *The psychology of written composition*, Hillsdale, NJ: Lawrence Erlbaum Associates.

Breese, C., Jackson, A., & Prince, T. (1996). Promise in impermanence: Children writing with unlimited access to word processors. *Early Child Development and Care*, *118*, 67-91.

Bruning, R., & Horn, C. (2000). Developing motivation to write. *Educational Psychologist*, *35* (1), 25-37.

Burstein, J., Chodorow, M., & Leacock, C. (2004). Automated essay evaluation: The criterion online writing service. *AI Magazine*, *25* (3), 27-36.

Burstein, J., Marcu, D., & Knight, K. (2003). Finding the WRITE stuff: Automatic identification of discourse structure in student essays. *IEEE Intelligent Systems*, *18* (1), 32-39.

Chan, T. W., Hue, C. W., Chou, C. Y., & Tzeng, O. J. L. (2001). Four spaces of network learning models. *Computers & Education*, *37* (2), 141-161.

Chang, L. J., Yang, J. C., Deng, Y. C., & Chan, T. W. (2003). EduXs: multilayer educational services platforms. *Computers & Education*, *41* (1), 1-18.

Daiute, C. (1985). Issues in using computers to socialize the writing process. *Educational Communication and Technology*, *33* (1), 41-50.

Falchikov, N. (1995). Peer feedback marking: Developing peer assessment. *Innovations in Education and Training International*, *32* (2), 175-187.

Flower, L., & Hayes, J. R. (1980). The dynamics of composing: Making plans and juggling constraints. In L. W. Gregg & E. R. Steinberg (Eds.), *Cognitive processes in writing*, Hillsdale, NJ: Lawrence Erlbaum, 31-50.

Flower, L., & Hayes, J. R. (1981). A cognitive process theory of writing. *College Composition and Communication*, *32* (4), 365-387.

Gillespie, M. K. (1999). Using research on writing. *Focus on Basics*, *3*, Issue D, retrieved April 2, 2005, from http://www.ncsall.net/?id=339.

Graesser, A. C., Hauft-Smith, K., Cohen, A. D., & Pyles, L. D. (1980). Advanced outlines, familiarity, text genre, and retention of prose. *Journal of Experimental Education*, *48*, 209-220.

Grejda, G. F., & Hannafin, M. J. (1992). Effects of word processing on sixth graders' holistic writing and revisions. *Journal of Educational Research*, *85* (3), 144-149.

Hertz-Lazarowitz, R., & Bar-Natan, I. (2002). Writing development of Arab and Jewish students using cooperative learning (CL) and computer mediating communication (CMC). *Computers & Education*, *39* (1), 19-36.

Hidi, S., Berndorff, D., & Ainley, M. (2002). Children's argument writing, interest and self-efficacy: An intervention study. *Learning and Instruction*, *12* (4), 429-446.

Hidi, S., & McLaren, J. (1991). Motivational factors and writing: The role of topic interestingness. *European Journal of Psychology of Education*, *6* (2), 187-197.

Ko, H. W., Chen, Y. W., & Wu, M. H. (Eds.). (2004). *Challenge Writing Environment*, Jhongli: National Central University (In Chinese).

Ko, H. W., Lee, H., & Lee, C. F. (1990). A study of common words and words difficulty for elementary school students: A case on sixth graders. *Unpublished technical report* (In Chinese).

Ko, H. W., & Yin, M. C. (1990). A study of common words and words difficulty for elementary school students: A case on first to third graders. *Unpublished technical report* (In Chinese).

Lam, F. S., & Pennington, M. C. (1995). The computer vs. the pen: A comparative study of word processing in a Hong Kong secondary classroom. *Computer Assisted Language Learning*, *8* (1), 75-92.

Lin, C. S. (1997). A study of computer-networked writing instruction in elementary school. *Unpublished doctoral dissertation* (In Chinese).

Lin, S. S. J., Liu, E. Z. F., & Yuan, S. M. (2001). Web-based peer assessment: feedback for students with various thinking-styles. *Journal of Computer Assisted Learning*, *17* (4), 420-432.

Rada, R. (1998). Efficiency and effectiveness in computer-supported peer-peer learning. *Computers & Education*, *30* (3-4), 137-146.

Renninger, K. A., Ewen, L., & Lasher, A. K. (2002). Individual interest as context in expository text and mathematical word problems. *Learning and Instruction*, *12* (4), 467-491.

Shermis, M. D., & Burstein, J. (Eds.). (2003). *Automated essay scoring: A cross-disciplinary perspective*, Hillsdale, NJ: Lawrence Erlbaum.

Topping, K. (1998). Peer assessment between students in colleges and universities. *Review of Educational Research*, *68* (3), 249-276.

Tsai, M. J. (1996). The effect of strategy teaching on text structure analysis for children to improve reading comprehension and writing skill. *Unpublished doctoral dissertation* (In Chinese).