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Enhancement of Elementary School Students' Science Learning by Web-Quest Supported Science Writing

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This study aimed to probe into the influence of implementing Web-quest supported science writing instruction on students' science learning and science writing. The subjects were 34 students in one class of grade six in an elementary school in Taiwan. The students participated in the instruction, which lasted for eight weeks. Data collection included Web-quest learning sheets, science writing learning sheets and interviews with students. The research findings demonstrated that Web-quest supported science writing instruction enhanced students' abilities to search by keywords, organize science contents and use scientific words. Students made significant progress in science writing and it revealed high and medium effect sizes. Changes in the students from the medium academic achievement group were the best and the difference was significant with a large effect size.

Keywords: elementary school student, science writing, Web-quest

Introduction

Scientific instruction generally focuses on learning scientific concepts and experiment manipulation, and neglects writing, which is commonly applied in language learning and is also important in science learning (Chuang & Hung, 2008). Hand, Hohenshell, and Prain (2004; 2007) suggested that the process of science writing could cultivate students' abilities to think, analyze and organize data as well as demonstrate the outcomes. In the science classroom, it is necessary for teachers to allow students to have time to respond and wait for students' answers. The strategy of science writing reveals similar advantages (J. G. Brooks & M. G. Brooks, 1993). Learning by writing allows students to think with more sufficient time and encourages students to learn new concepts using prior knowledge.

The rise of the Internet has changed traditional science instruction and learning and provides richer and more diverse measures than the textbook-oriented instruction of the past (Schneider, Krajcik, & Blumenfeld, 2005). In the adoption of Web-quest supported instruction, teachers should guide students to collect data using computers, instruct them how to analyze data and encourage their thinking (Schneider et al., 2005). It helps students to learn and decreases their learning burdens.

Marlene and Bennett (2002) suggested that it is effective for language teachers to teach students writing skills that organize contents and guide students to present scientific themes. Therefore, treating rich online information as a source of scientific learning materials and support for writing teachers' writing instructions can also be useful for science learning and instruction.

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Based on the above, this study aimed to probe into the influence of Web-quest supported science writing instruction on students' science learning and science writing and the effects on students from different academic achievement groups. The research questions are shown as follows:

(1) In the implementation of Web-quest supported science writing instruction, how do students change their science learning? Is there a performance difference in students' science writing before and after instruction?

(2) In the implementation of Web-quest supported science writing instruction, is there a performance difference in the science writing of students from different academic achievement groups?

Literature Review

Web-Quest Instruction and Learning

Information-based instruction is an important educational principle implemented in high schools and elementary schools by the Ministry of Education in Taiwan. With the rise of the Internet, Enochsson (2005) suggested increasing students' learning motivations, learning interests and learning achievements, as well as cultivating problem-solving abilities through online learning. There is rich information available online that can give students more learning opportunities. Jonassen (2000) indicated that teachers could instruct students to have effective online searches through seven steps: planning, online searching using tools or strategies, evaluating the usability of information, the use of secondary data sources, data criticism and evaluation, collecting and using the information and students' self-reflection on search learning. Enochsson (2005) also suggested that by different measures and approaches, students could construct different scientific concepts and knowledge learning. The Internet provides multiple knowledge sources and students can use online knowledge databases, according to their interest or course contents, in order to obtain knowledge data and use the learning strategy of meta-level comprehension (Kuhn, 2005), which will result in meaningful learning.

Instruction and Learning of Science Writing

Science writing is a high-level cognitive thinking activity. Without the guidance of proper themes or teachers' instruction, students will spend more time adapting to the learning (Kuhn, 2005; Marlene & Bennett, 2002). When students learn science by writing, they usually do not know how to start (Hand et al., 2004; 2007). The reason can be that no one has taught them how to write.

In science instruction and the learning of science writing, science teachers often do not know how to instruct students to write (Hand et al., 2004, 2007; Kuhn, 2005; Marlene & Bennett, 2002). In science writing, students tend to rely on their memories and they cannot control and select learning themes and contents. They have difficulties to start writing, since they do not know how to demonstrate their comprehension of learning contents by writing. Therefore, in the design of scientific instruction, if teachers can guide students' writing using a scaffold, they can enhance students' science learning (Gunel, Hand, & Prain, 2007).

Wellington and Osborne (2001) suggested that in science learning, the adoption of DARTs (directed activities related to texts) could increase students' quality of science writing. There are two methods: reconstruction and analysis. The former provides deconstructed components for learners to reorganize using processed articles and the latter means to allow learners to analyze the contents of unprocessed articles. DARTs not only meet the goal of active reading, but also allow writing to be presented. In reading and writing, students can review the textbooks, exercise books or other references. They meet the purpose of overall reading and writing instruction upon reading in writing and writing in reading. Akkusa, Gunelb, and Hand (2007) and Gunel et al. (2007) indicated that teachers must provide specific writing themes and framework, otherwise, students could fail the writing and they might lose writing interests and motivations. Therefore, in writing, a writing framework presentation and the use of vocabulary should be concerned. Related concepts or content should be offered in order to increase readability. In addition, a description of the aims of writing should be clear (Chuang & Hung, 2008) to help students organize their thinking using logical thoughts.

In science instruction, science teachers can extend students' learning content using diverse online data sources. In addition, language teachers' writing guidance could possibly help students have meta-learning through science writing. When students express their thoughts in writing, they comprehend and monitor their learning (Conner, 2007). Thus, students will further establish the comprehension of science knowledge and accomplish the goal of science learning. Web-quest supported science writing allows students to have multiple exploration and learning, and their potentials can be fully demonstrated.

Methods

Roles and Functions of Web-Quest and Science Writing in This Study

Web-quest instruction provides students with a scaffold to learn science contents and it is the source of knowledge to support science writing. In this study, science writing aimed to teach students how to reorganize Web-quest information and have effective meta-reorganization of scientific concept learning in science writing.

Themes of Instruction

This study treated the "Introduction of the World of Animals" and the "Reproduction of Creatures" in the grade six science course of an elementary school in Taiwan as the themes of instruction. The "Introduction of the World of Animals" emphasized the animals' living behaviors and introduced the grouping environment. The contents were rich and indicated specific themes related to animals. As to the "Reproduction of Creatures", it emphasized the characteristics and classification of different reproductive behaviors between animals and plants. It revealed positive scientific themes and specific scientific concepts. The two units were related. Web-quest supported science writing was suitable for this science learning.

Stages of Instruction

The instruction included the following stages:

(1) Web-quest instruction: Science teachers taught students to have scientifically themed learning using online search tools and instructed students to search using keywords and obtain data in order to result in new learning;

(2) Guidance of science writing: Language teachers (with the experience of science teaching) taught students to perform science writing using information obtained by Web-quest. Reading and writing instructions were designed by reconstruction using DARTs indicated by Wellington and Osborne (2001);

(3) Science writing stage: Students researched online information and reconstructed complete science writing;

(4) Evaluation: Students' science writing was evaluated and students were interviewed in order to recognize the influence of Web-quest supported science writing instruction on students' learning.

Research Instruments

Interview. The subjects of the interview were two students respectively from the groups with high, medium and low average scores in Mandarin and natural science. The interview included two stages. In the first stage, writing collaborative instruction was intervened for the first time. In the second stage, writing collaborative instruction ended.

Science writing scale. The science writing scale in this study was based on the key points of science writing suggested by Su and Lo (2007), Chuang and Hung (2008) and Taylor (2007). Scientific education experts and science teachers examined the scoring and content of the scale and established content validity of the scale. As to the evaluation on students' science writing, two science teachers with a science education background were invited to explain and discuss the scoring. Upon the common consensus, the two scorers' Pearson product-moment correlation coefficient of 0.86 was obtained. This demonstrated that two teachers' scoring on students' science writing reached consistency reliability. When they had different opinions, they would discuss the issues until they had a common consensus.

Data Analysis

Data analysis was based on the suggestion of Patton (1990) that original data are collected and then reorganized and classified to be easily distinguished and integrated. Students' science writing was scored by the science writing scale. This study used SPSS12.0 to conduct descriptive statistics and single-group pre-test and post-test dependency sample *t*-test to recognize the influence of Web-quest supported science writing instruction on students' science learning. According to the students' average achievements in language and natural science, the participants were divided into low, medium and high academic achievement groups. ANOVA (analysis of variance) was conducted upon the groups as independent variables and changes in science writing (post-test subtracted by pre-test) as dependent variables to probe into the influences of Web-quest supported science writing instruction on the performances of students in different academic achievement groups.

Results

Students' Change in Science Learning and Change of Science Writing Performance

Reinforcement of students' abilities to explore scientific concepts by key words. At the beginning of the instruction, students were unfamiliar with skills of Web-quest and they did not know how to select the data obtained. Under teachers' guidance, students analyzed scientific concepts of themes in science textbooks and had Web-quest by theme concept as key words. After instruction, students could rapidly search the related information. In the interview, S16 suggested, "At the beginning, I do not know how to search data. After teachers' instruction of use of key words, I keyed in 'reproduction of Taiwan macaque' and found many related Websites". S23 also suggested, "I treated 'viviparity' as the key word and found many information about viviparous creatures, including animals and plants". After observing the classroom, language teachers realized following, "I saw students searching information by the combination of two key words 'animal + reproduction'". After science teachers guide students to analyze scientific themes and determine key words, students' abilities to use Web-quest are increased.

Change of ability to reorganize data. In class of writing instruction, language teachers asked students to print out information searched and bring it to the class. They taught students to read the information, summarize and reorganize the contents. S7 suggested, "The teacher asked us to read the information first, taught us how to recognize the key points and reorganize them". After the instruction, students gradually realized how to reorganize important contents and describe the information and reconstruct their writing. S7 continued, "I realized that I could write down characteristics of different kinds of reproduction". S28 also indicated, "I read the information first according to teachers' instruction and recognized the important content. I then knew how to start writing".

Increase of using vocabularies capacity. The researcher compared students' science writing before and after the instruction and realized that students' abilities to use scientific vocabulary were enhanced. Before, students only used the words in science textbooks. However, after instruction, they would use more science vocabularies. Science writing of S7 before and after the instruction was an example. After receiving Web-quest supported science writing instruction, students had easy access to writing content. Students gradually organize writing content by richer scientific vocabularies and more completely described the scientific contents.

> After mating, animals reproduce the next generation. Animals could be divided into viviparity, oviparity and ovo-viviparity. For instance, chickens are oviparous animals, monkeys are viviparous animals and snakes are ovo-viviparous animals. (S7' science writing pre-test)

> Animal reproduction includes three steps: courtship, mating and reproduction. Reproduction is the most important mission of animals. Animal reproduction is divided into viviparity, oviparity and ovo-viviparity. Viviparity means to grow in mother's body and nutrition is from the mother's body and nutrition of oviparity is from the egg. However, the animals which grow in mothers' bodies are more likely to survive. On the contrary, oviparous animals have less chance to survive. For instance, monkeys are organizational social animals. Thus, small monkeys have more protection. On the contrary, although fish reproduce thousands of eggs, the eggs can hardly survive and be protected. (S7' science writing post-test)

Science Writing Performance Before and After Instruction

Dependent sample *t*-test of one-group pre-test and post-test is conducted on scoring of the first and second writing by SPSS12.0. As Table 1 shows, "cognition of scientific concepts", after the instruction, M (post) = 3.82 which is higher than M (pre) = 3.43 before the instruction and the difference is significant, d = 0.43 and it is nearly medium effect size (according to Cohen (1977), d = 0.2, d = 0.5, d = 0.8 refer to low, medium and high effect sizes). As to "organization of scientific contents", M (post) = 3.69 which is higher than M (pre) = 3.19. The difference is significant, d = 0.80 which reveals high effect size. As to "expression of scientific vocabularies", M (pre) = 3.36 and M (post) = 3.74. Difference is significant, d = 0.56, which reveals medium and high effect sizes. Mean of overall science writing quality after instruction is 11.26 and it is higher than mean = 9.98 before instruction. T = -10.40 and difference is significant, d = 0.63 which reveals medium and high effect sizes.

Table 1

Comparison of Pre-test and Post-test on Science Writing Scale (N = 34)

Science writing scale	Test	M (Mean)	SD (Standard deviation)	t (t-value)	d (Cohen's d)	Effect size
Cognition of scientific concepts	Pre-test	3.43	0.93	-9.37^{***}	0.43	Medium
	Post-test	3.82	0.87			
Organization of scientific contents	Pre-test	3.19	0.66	-10.10^{***}	0.80	High
	Post-test	3.69	0.55			
Expression of scientific vocabularies	Pre-test	3.36	0.76	-4.40^{***}	0.56	Medium
	Post-test	3.74	0.59			
Total	Pre-test	9.98	2.15	-10.40^{***}	0.63	Medium
	Post-test	11.25	1.91			

Note. $^{***}p < 0.001$.

Performances of Different Academic Achievement Groups

The researcher tried to find which group of students was benefited by Web-quest collaborative writing most. Different academic achievement groups were treated as independent variables and the change of science writing in post-test and pre-test was treated as dependent variables. After test of homogeneity of variance, Levene statistics $F_{(2,31)} = 1.823$ and $p = 0.179 > 0.05$ which are insignificant and does not violate test of homogeneity of variance. Null hypothesis is accepted. It means three groups of variance are no difference. ANOVA result (see Table 2) demonstrates that between-group effect test is significant. $F_{(2,31)} = 6.433$, $p = 0.005 < 0.05$ and effect size is 0.293. According to suggestion of Cohen (1988), $\eta^2 = 0.01$, $\eta^2 = 0.06$ and $\eta^2 = 0.14$ are representatives of small, medium and large effect sizes. Therefore, when effect size is large, it means average difference of change in science writing of students in different academic achievement groups is significant. There is large effect size. According to Scheffe posterior comparison, in change of science writing, *MS'* (*h*) = 0.800, *MS'* (*m*) = 1.411 and *MS'* (*l*) = 1.275. It demonstrates that change in medium academic achievement group is the most significant and it is higher than high academic achievement group.

As to "cognition of scientific concepts", Levene statistics $F_{(2,31)} = 0.003$ and $p = 0.997 > 0.05$. "Organization of scientific contents" refers to $F_{(2,31)} = 0.868$ and $p = 0.430 > 0.05$. "Expression of scientific vocabularies" refers to $F_{(2,31)} = 0.483$ and $p = 0.621 > 0.05$. They are insignificant and do not violate test of homogeneity of variance. Null hypothesis is accepted and there is no difference among three groups of variance. ANOVA result is showed in Table 2. Between-group test of "cognition of scientific concepts" is significant. $F_{(2,31)} = 3.728$, $p = 0.035 < 0.05$ and $\eta^2 = 0.194$. It means that means of change in science concept cognition of students in different academic achievement groups are significantly different. It reveals large effect size. Between-group effect test of "organization of scientific contents" is significant. $F_{(2,31)} = 5.897$, $p = 0.007 < 0.05$ and $\eta^2 = 0.276$. It means averages of change in "organization of scientific contents" in students of different academic achievement groups are significant. There is large effect size. As too "expression of scientific vocabularies", between-group effect test is $F_{(2,31)} = 0.297$ and $p = 0.745 > 0.05$. Means of change in "expression of scientific vocabularies" are insignificant.

Table 2

Test of Change of Science Writing Scales Between Different Academic Achievement Groups' Effect

Science writing scales	Source	*SS'* (Sum of Squares)	*Df* (Degree of Freedom)	*MS'* (Mean Squares)	*F* (F-value)	*P* (P-value)	η^2(Eta squared)
Cognition of scientific concepts	Groups	0.272	2	0.136	3.728	0.035	0.194
	Error	1.132	31	0.037			
	Corrected total	1.404	33				
Organization of scientific contents	Groups	0.736	2	0.368	5.897	0.007	0.276
	Error	1.935	31	0.062			
	Corrected total	2.671	33				
Expression of scientific vocabularies	Groups	0.046	2	0.023	0.297	0.745	0.019
	Error	2.419	31	0.078			
	Corrected total	2.465	33				
Total scales	Groups	2.275	2	1.138	6.433	0.005	0.293
	Error	5.482	31	0.177			
	Corrected total	7.757	33				

Scheffe posterior comparison is conducted on students of high, medium, low academic achievement groups regarding "change of science writing evaluation". As shown in Figure 1, change of "cognition of scientific concepts" refers to *MS'* (*h*) = 0.250, *MS'* (*m*) = 0.464 and *MS'* (*l*) = 0.400. Medium academic achievement group is higher than high academic achievement group. Change of "organization of scientific contents" refers to *MS'* (*h*) = 0.250, *MS'* (*m*) = 0.571 and *MS'* (*l*) = 0.575. Medium academic achievement group is higher than high academic achievement group and low academic achievement group is higher than high academic achievement group. As to "expression of scientific vocabularies" refers to *MS'* (*h*) = 0.300, *MS'* (*m*) = 0.375 and *MS'* (*l*) = 0.300, means of change of three groups are not significantly different.

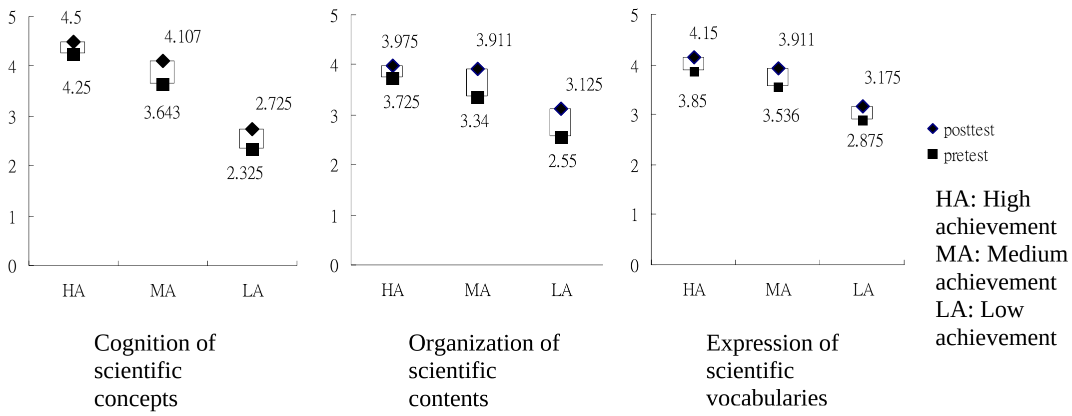

Figure 1. Mean of change in science writing evaluation dimension.

Discussions

With teachers' guidance, students make progress in Web-quest search ability. Students' use of key words, ability to obtain information and browsing efficacy are also reinforced. The result is similar to researches of Enochsson (2005) and Hwang, Kuo, and Tsai (2009). It also meets the suggestion of C. C. Lin, T. Y. Yang, Wang, K. Y. Lin, Yu, and H. T. Yang (2009) that teachers should guide students to increase online search ability.

At the beginning of the instruction, as suggested by Hand et al. (2004), in science writing, students usually do not know how to write, since they do not find proper materials and content. However, after Web-quest supported science writing instruction, as emphasized by Akkusa et al. (2007), Cervetti, Pearson, Bravo, and Barber (2005), Chuang and Hung (2008) and Gunel et al. (2007), in science courses, teachers should provide students scaffold to help students select the key points representing critical scientific concepts by books and media tools in order to communicate with others regarding their recognition and thoughts on science content. As suggested by Marlene and Bennett (2002), with scaffold upon writing instruction as demonstration, students will know how to start writing. Students' complete science learning can be constructed through writing.

According to students' science writing quality, students make significant progress after collaborative instruction. It demonstrates that Web-quest collaborative instruction enhances students' learning in science. Among students of different groups, medium academic achievement students are influenced the most. Guidance by instruction enhances students' writing performance and science learning. It is similar to studies of Lin, W. P. Chang, and H. P. Chang (2007) Marlene and Bennett (2002). However, "science vocabulary expression" does not reveal significant difference. The researcher suggests that the reason can be in that conceptual learning and data sources all clearly indicate scientific vocabulary of the units. Thus, students can easily use them.

Based on result above, Web-quest supported science writing instruction provides complete learning process for students and helps students integrate data searched. It positively increases comprehension in writing expression and it also allows students to develop meaningful learning in scientific concepts.

Conclusions

After Web-quest supported science writing instruction, students' Web-quest abilities, data reorganization abilities and science writing by scientific vocabulary are reinforced. Students' science writing after instruction is better than that before instruction. It demonstrates that Web-quest supported science writing instruction significantly enhances students' performances in science writing and it reaches at least medium effect size. It can be implemented in instructional practice.

According to variable analysis change in pre-test and post-test of "science writing evaluation" regarding students in different academic achievement groups, as to theme "cognition of scientific concepts", change of medium academic achievement group is higher than change of high academic achievement group and it reaches large effect size. In "organization of scientific contents", change in medium and low academic achievement groups is higher than high academic achievement group and it reaches large effect size. As to "expression of scientific vocabularies", the difference is insignificant. Regarding overall performance, change of medium academic achievement group is higher than high academic achievement group and it reaches large effect size. It demonstrates that influence of Web-quest supported science writing instruction on medium academic achievement group is the most significant.

Suggestions

Teachers in elementary schools in Taiwan must instruct multiple courses. In this study, language teachers have experience of both language and science instruction and they are different from pure language teachers. Will they have different teaching perspectives when instructing students' science writing? It will rely on further study. Research conclusion demonstrates that the influence on medium academic achievement group is the most significant. Does it reveal ceiling effect on high academic achievement group? It will rely on in-depth researches in the future.

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